OLDMAN RIVER DAM PROJECT

FISHERIES EVALUATION PROGRAM

- 1989 ANNUAL REPORT -

Prepared for

ALBERTA PUBLIC WORKS

SUPPLY AND SERVICES

by

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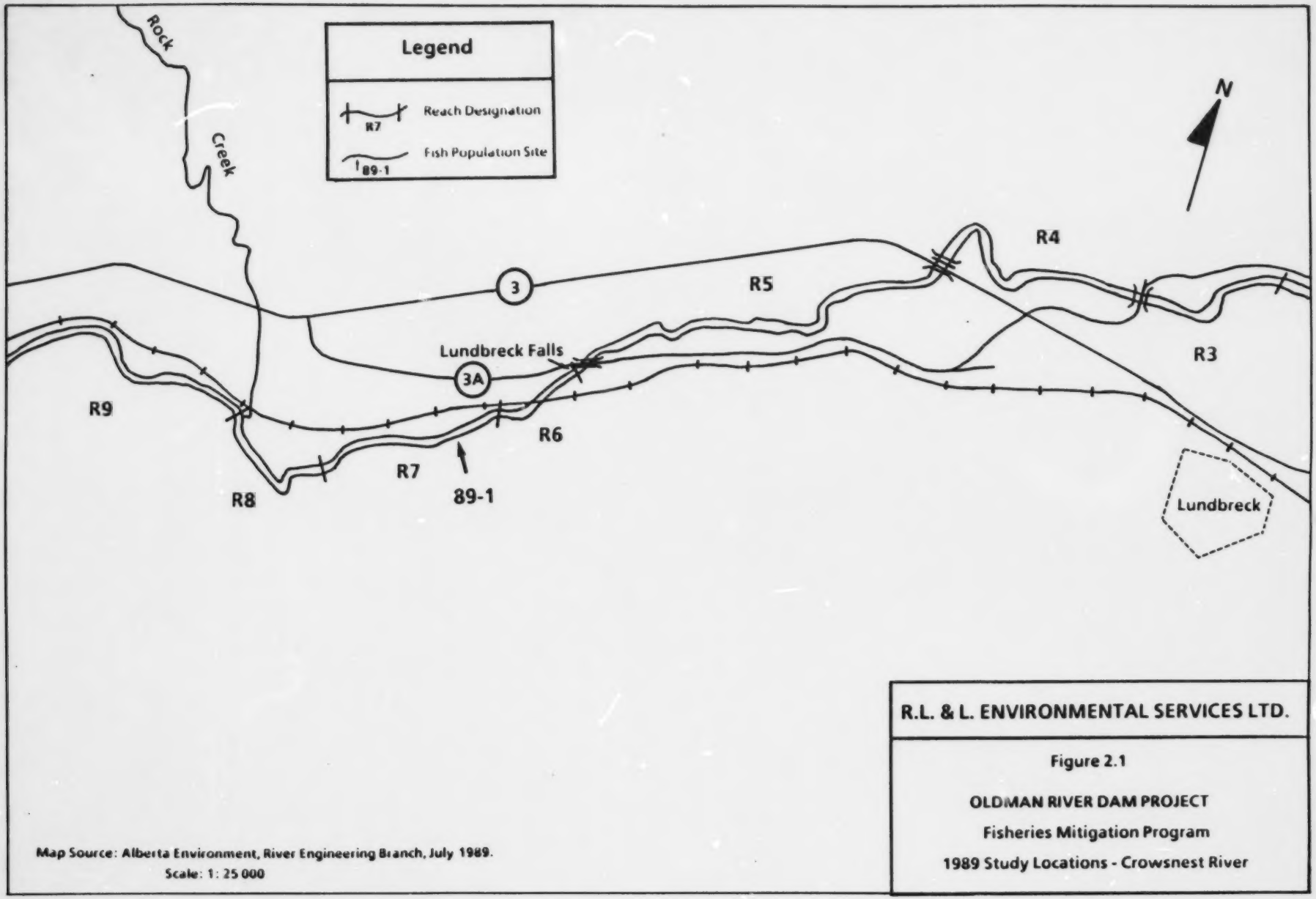
SECTION 1.0
INTRODUCTION

Alberta Public Works, Supply and Services, in cooperation with the Alberta Fish and Wildlife Division, is presently implementing a large-scale habitat enhancement program on the Crowsnest River. The intent is to offset fisheries losses due to the Oldman River Dam currently under construction near Pincher Creek, Alberta. Under the guidance of the Fisheries Mitigation Working Group (FMWG), R.L. & L. Environmental Services Ltd. was asked in 1987 to obtain detailed estimates of population density and biomass for sportfish species at sites selected for habitat improvement. Sampling during the 1989 field season represents the third year of detailed sampling on the Crowsnest River, upstream of reservoir full supply level (FSL). One phase of the 1989 program involved sampling at sites previously investigated in late summer 1988 to determine fish population response to enhancement structures constructed in fall 1988. The second 1989 study component involved pre-construction sampling of sites potentially targetted for enhancement in 1990 (or later). Several control sites also were sampled in order to assess natural population fluctuations in natural high and low quality habitats.

SECTION 2.0
STUDY LOCATION

In total, 20 sites were investigated in 1989. The work was conducted during the period 9-30 September. Of the 20 population estimates derived, one was in the Lundbreck area (Figure 2.1), five were near Burmis (Figure 2.2), three were situated near Hillcrest (Figure 2.3), and five were adjacent to the Frank Industrial Park (Figure 2.3). The remaining six sites were within and upstream of Coleman (Figure 2.4). The sites at Lundbreck and Burmis provided baseline data for possible future enhancement activities in these reaches. The Coleman sites were sampled to provide pre-enhancement data prior to construction in the fall of 1989. The sites at Frank and Hillcrest were post-enhancement in nature (i.e., sampled to provide comparison between pre-construction data generated in 1988 and post-construction conditions in the current year).



Map Source: Alberta Environment, River Engineering Branch, July 1989.
Scale: 1: 25 000

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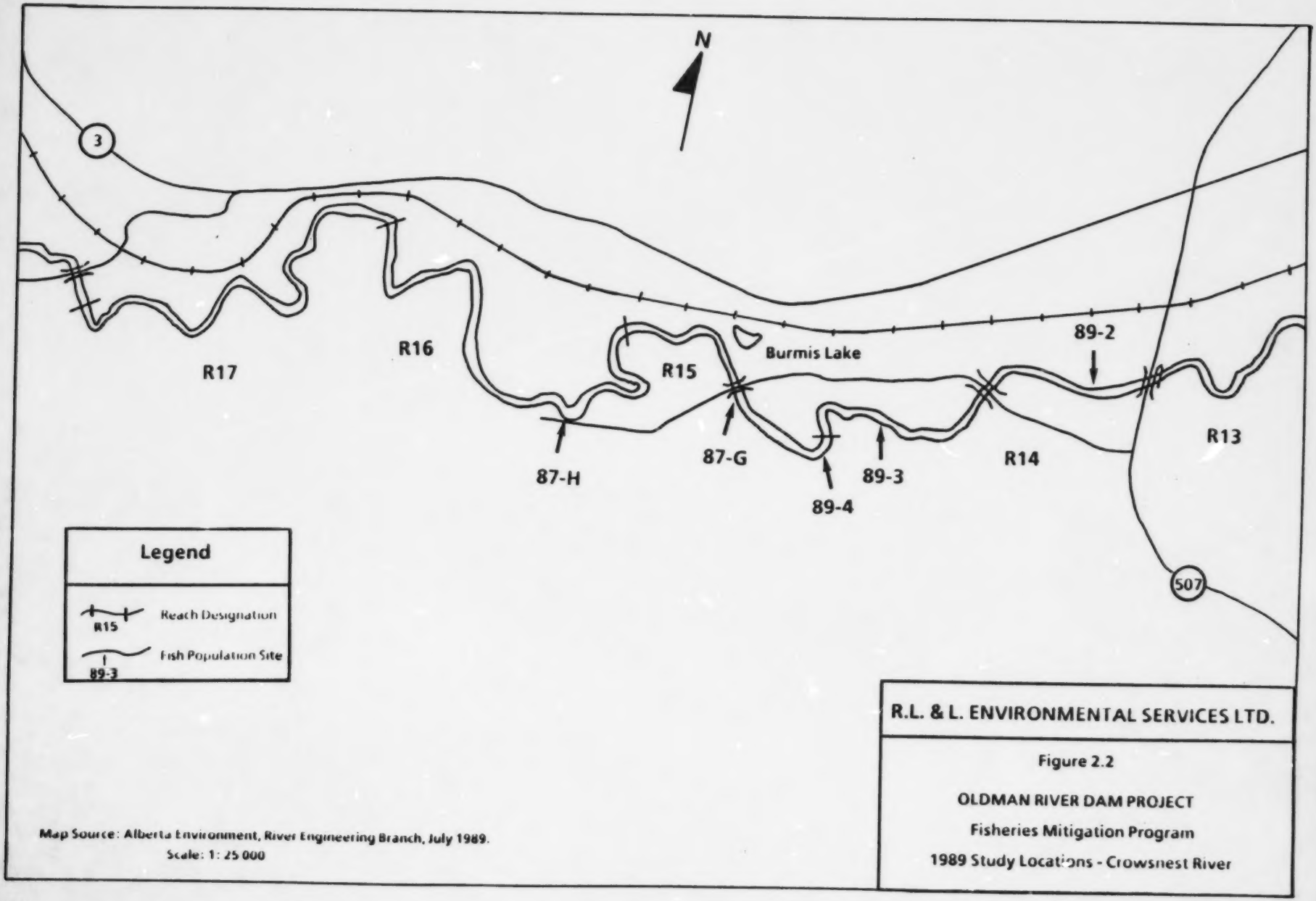
Figure 2.1

OLDMAN RIVER DAM PROJECT

Fisheries Mitigation Program

1989 Study Locations - Crowsnest River



Map Source: Alberta Environment, River Engineering Branch, July 1989.
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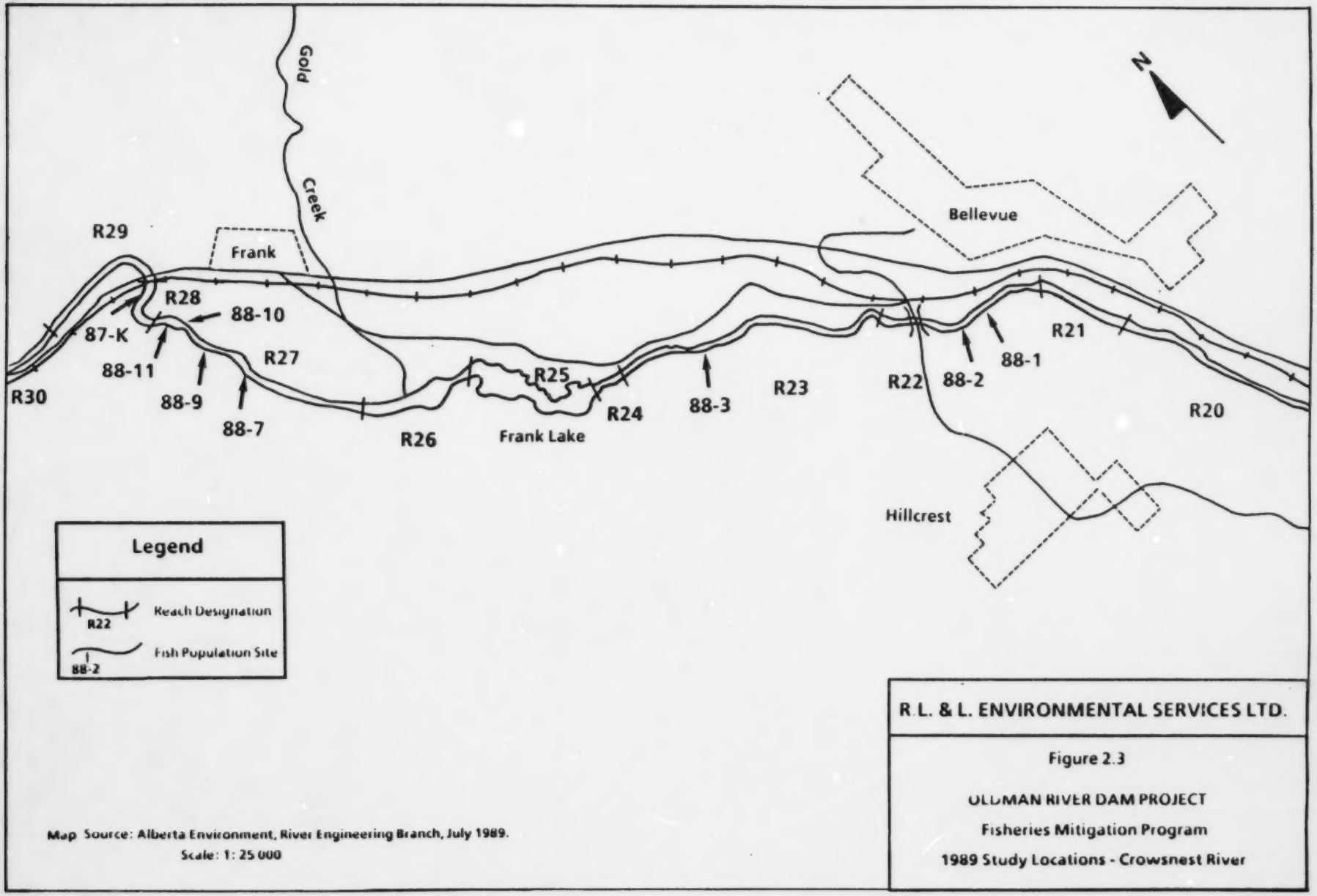
Figure 2.2

OLDMAN RIVER DAM PROJECT

Fisheries Mitigation Program

1989 Study Locations - Crowsnest River



Map Source: Alberta Environment, River Engineering Branch, July 1989.
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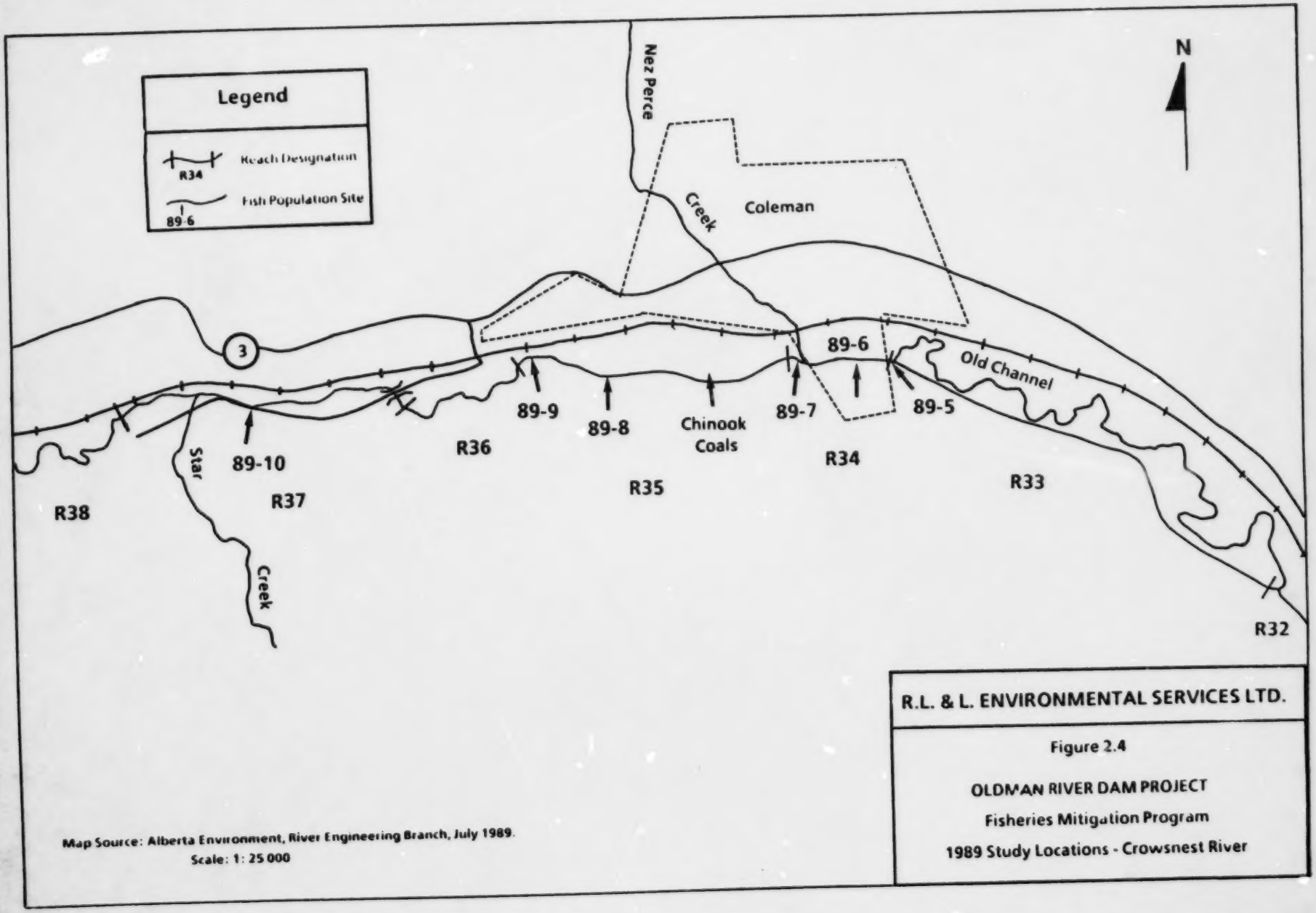
Figure 2.3

OLDMAN RIVER DAM PROJECT

Fisheries Mitigation Program

1989 Study Locations - Crowsnest River



Map Source: Alberta Environment, River Engineering Branch, July 1989.
Scale: 1: 25 000

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Figure 2.4

OLDMAN RIVER DAM PROJECT

Fisheries Mitigation Program

1989 Study Locations - Crowsnest River

SECTION 3.0
METHODOLOGY

Fish population survey sites were established at 20 locations on the Crowsnest River (Figures 2.1 to 2.4). These locations included post-enhancement sites (habitat enhancement structures constructed in 1988) and pre-enhancement sites (locations selected for enhancement in the fall of 1989 or subsequent years).

At each population survey site, block nets consisting of 1.5 cm stretched measure mesh were positioned at the upstream and downstream ends. The nets were placed across the channel to produce a total barrier to fish movement. A weighted nylon skirt, attached to the bottom of the net, prevented fish movement under the net.

Once the block nets were in place, a multi-pass removal-depletion capture strategy was utilized to obtain an estimate of sportfish populations within the enclosed area. Fish were captured using a Smith-Root type VI-A electrofishing system powered by a 4000 W generator. The electrofishing system was mounted in an inflatable boat to facilitate movement within the survey area. In shallow sections (i.e., <1 m depth), the electrofisher operator (using a hand-held anode and a towed cathode apparatus), waded in the channel accompanied by one or more netters. One removal run generally consisted of an upstream and a downstream pass through the enclosed area. The relative degree of sampling effort (i.e., seconds shocked), sampling pattern, and area sampled were maintained as constant as possible during each run. A minimum of three runs were required to capture sufficient numbers of sportfish to obtain the necessary level of precision for the population estimate. Additional runs were required at some sites.

Captured fish were removed to a holding tank which was placed near shore at the downstream end of the enclosed section. Fish were identified, enumerated and measured prior to their release downstream of the lower block net. Life history data collected included length (fork length to nearest mm) and weight. Only a representative subsample of smaller fish were weighed if large numbers (i.e., >100 per run) were present. Fish were weighed with digital electronic balances (accurate to ± 1 g).

Prior to detailed analyses (i.e., population and biomass estimates) the data for rainbow trout and mountain whitefish where separated into distinct size-classes based on fish length. These were young-of-the-year (y-o-y), juveniles, and legal or adult size-classes. To accomplish this, the length-frequency distribution for each species were assessed at a particular site. From this information the length classes for y-o-y and juvenile fish were established. Legal or adult fish were ≥ 254 mm in length.

Fish population density estimates were derived using the removal-depletion method according to Zippin (1958) and through application of the maximum-likelihood estimator as recommended by Van Deventer and Platts (1983). The computer software package MICROFISH V2.3 (Van Deventer and Platts 1987) was utilized to complete the calculations. To facilitate comparisons, the estimates were standardized to number of fish/100 m units.

Standing stock biomass was estimated for specific size-classes of fish by using the population estimate and the mean weight of fish in a specific size-class. Based on the weighed subsample of fish, a length-weight regression was calculated, and this relationship was used to estimate the weight of fish for which only a length was obtained. The mean weight of a fish in a given size-class was then calculated from the complete data set, and this value was used to estimate biomass. Confidence intervals (95% level) were estimated using the formulae presented in Armour et al. (1983). The biomass estimates were standardized to kg/ha units by dividing the biomass estimate by the wetted area of the stream section sampled.

Physical habitat characteristics were recorded at each site. Depth, velocity (0.6 d), and substrate data were obtained at pre-designated transects. In addition, the distribution and area of the various habitat types within each site were estimated. A field diagram was prepared illustrating major habitat features, transect locations and the habitat type/distribution within cells between transects. Habitat and substrate terminology are described in Appendix A of the 1988 evaluation report (RL&L 1989).

SECTION 4.0
POST-ENHANCEMENT RESULTS

4.1 RESULTS OF 1989 SAMPLING PROGRAM - POST-ENHANCEMENT

4.1.1 Location and Description of Post-Enhancement and Control Population Sites

Eight post-enhancement population estimates were derived in 1989, including estimates at six sites enhanced in the previous year (i.e., fall 1988) and two natural control sites (Table 4.1). Three of the sites were situated in the vicinity of Hillcrest and five were located adjacent to the Frank Industrial Park (Figure 2.3). Each of the sites was sampled in 1988 prior to instream enhancement activities; two of the sites (i.e., 87-3 and 87-K) were high quality natural habitats which were selected as CONTROL sites for the respective enhancement areas. The majority of the sites upgraded were shallow run (R3) type habitats considered to have low adult feeding/holding capability. Site 88-2 was a natural R2 habitat that was upgraded through addition of large boulders. A variety of habitat

enhancement structure types were evaluated in the 1989 program including groynes, boulder placement, V-weirs, bank overhang, and a log wall.

Table 4.1 Location and description of post-enhancement and control population sites, 1989.

Enhancement Area	Site Designation	Habitat Type/Description	
		Pre-Construction (1988)	Post-Construction (1989)
Hillcrest	88-1	Natural R3	Groyne Run/boulder garden
	88-2	Natural R2 (R3, RF/BG)	R2/Boulder garden
	88-3 (Control)	Natural R2 (R3)	Natural R2 (R3)
Frank	88-7	Natural R3	V-weir
	88-9	Natural R3	V-weir
	88-10	Natural R3 (R2)	Bank overhang/boulder garden
	88-11	Natural R3	Log wall/bank overhang/ boulder garden
	87-K (Control)	Natural R1/P1	Natural R1/P1

Streamflows during the 1989 sampling program ranged from 3.3 $m^3 \cdot s^{-1}$ at the Hillcrest sites during the survey period (16-19 September) to 2.5 $m^3 \cdot s^{-1}$ at the Frank sites during the period 26-30 September. Flows of this magnitude were similar to the long term average for the month of September (i.e., 2.96 $m^3 \cdot s^{-1}$; 1910-1988 period of record, Water Survey of Canada). This is in contrast to the flows experienced during the 1988 field season. During 1988, sampling occurred during the period 15-25 August at flows of 1.6 $m^3 \cdot s^{-1}$. Flows of this magnitude are substantially below the long-term average for the month of August (i.e., 3.87 $m^3 \cdot s^{-1}$) and approximately 40-50% lower than experienced in 1989.

4.2 NUMBERS AND PERCENTAGE COMPOSITION OF CATCH

Table 4.2 summarizes the catch from the eight sites during 1988 (prior to enhancement) and 1989 (one year following enhancement). In 1988, 3053 fish were enumerated, of which 1789 (59% of the total) were rainbow trout. Mountain whitefish also were numerous at the various sites (i.e., 1167 captured, 38% of total). Brook trout made a minor contribution to the 1988 catch. Three non-sport species also were represented which included longnose sucker, mountain sucker, and longnose dace.

The species composition in 1989 was similar to that recorded in 1988 with the exception of rainbow/cutthroat hybrids which were only encountered in the current year. It is possible that this species was present in 1988 but was not detected. Rainbow trout remained the dominant species in

1989 (2478 individuals, 52% of the total catch). Mountain whitefish also were strongly represented in the catch (2140 individuals, 45% of total catch). Numbers of several species appeared to decline (i.e., suckers, longnose dace, brook trout); this was probably due to the alteration of the habitat from shallow riffle/run types to deeper faster habitats.

Table 4.2 Number and percentage composition of fish captured at enhanced and control sites on the Crowsnest River during 1988 and 1989, (pre and post-construction).

Species	No. Captured		% Composition	
	1988 (pre)	1989 (post)	1988 (pre)	1989 (post)
Rainbow trout	1789	2478	59	52
Brook trout	14	3	<1	<1
Cutthroat trout[a]	0	16	<1	<1
Mountain whitefish	1167	2140	38	45
Longnose sucker	9	2	1	<1
Mountain sucker	30	67	<1	1
Longnose dace	44	73	1	2
	3053	4779	100	100

[a]Rainbow/cutthroat hybrids.

4.3 SIZE DISTRIBUTION OF CATCH

4.3.1 Rainbow Trout

The size distribution of rainbow trout encountered at the eight population sites during the 1988 pre-enhancement and 1989 post-enhancement sampling programs is illustrated in Figure 4.1. The raw data for the length-frequency analyses is provided in Appendix B, Table B1.

Site 88-1 (Natural R3 to Groyne Run-Boulder Garden)

Site 88-1 was upgraded from a shallow run (R3) to a groyne-run boulder garden. The length-frequency distribution does not show any major shifts, although there was an apparent decrease in the relative contribution of y-o-y. This event could have been due to year-class variability or flow differences between years.

Site 88-2 (Natural R2 (R3, RF-BG) to R2-Boulder Garden)

Site 88-2 was upgraded through the addition of large boulders. No striking differences between years are evident. Further evaluation will be required to determine the long-term effectiveness of the enhancement action.

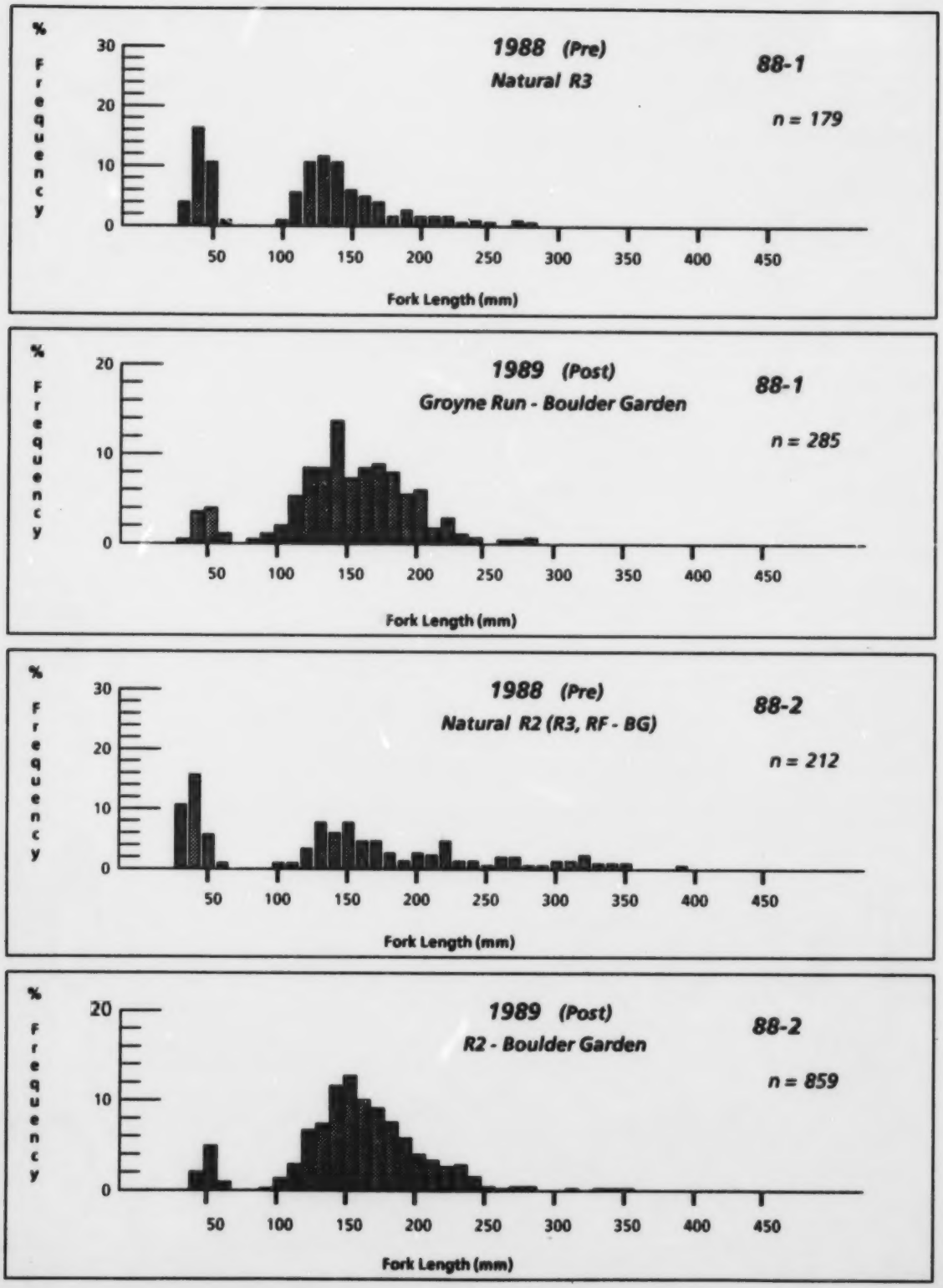
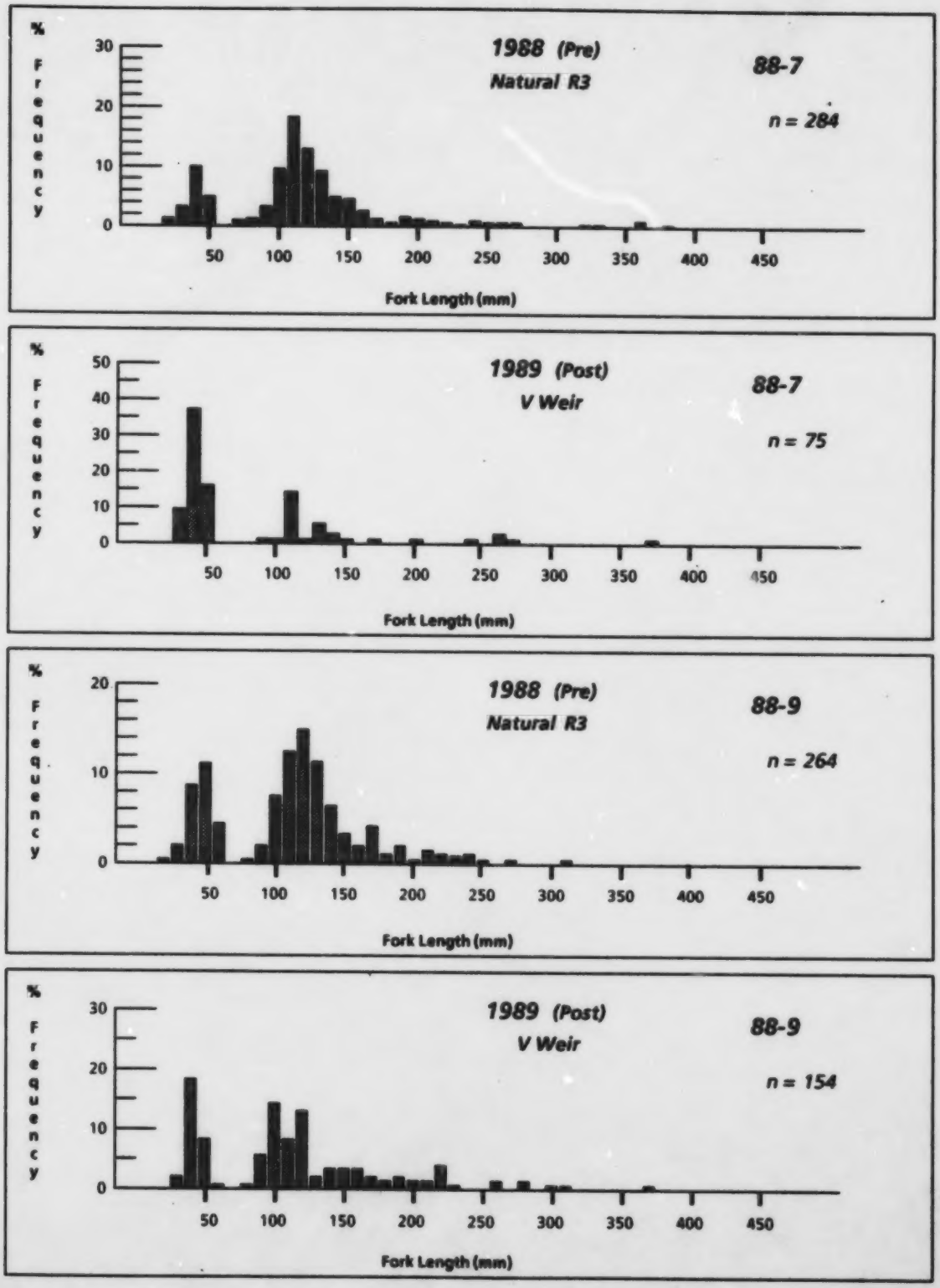


Figure 4.1 Length-frequency distribution of rainbow trout from enhanced and control sites on the Crowsnest River during 1988 and 1989, (pre and post-construction) .



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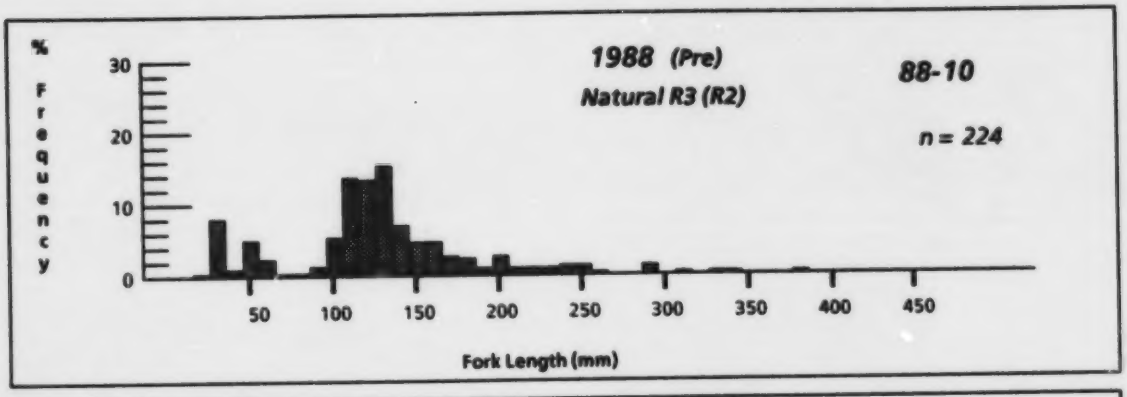
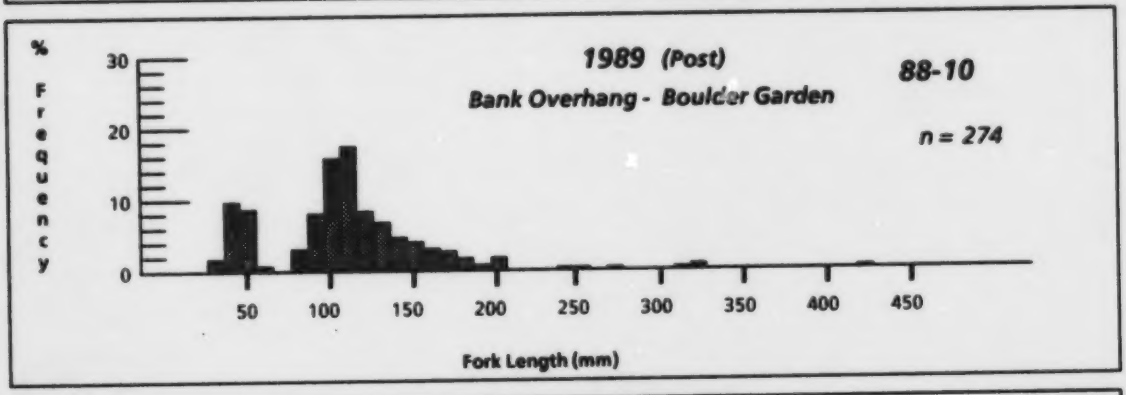
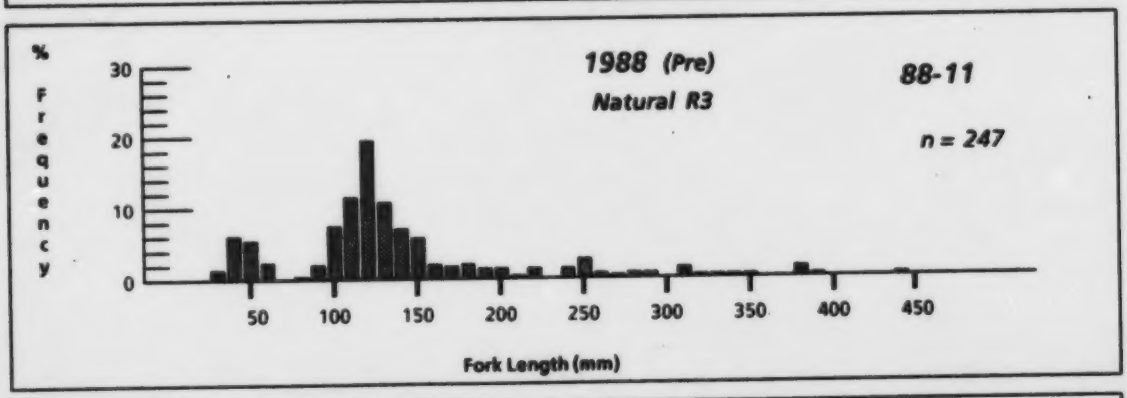






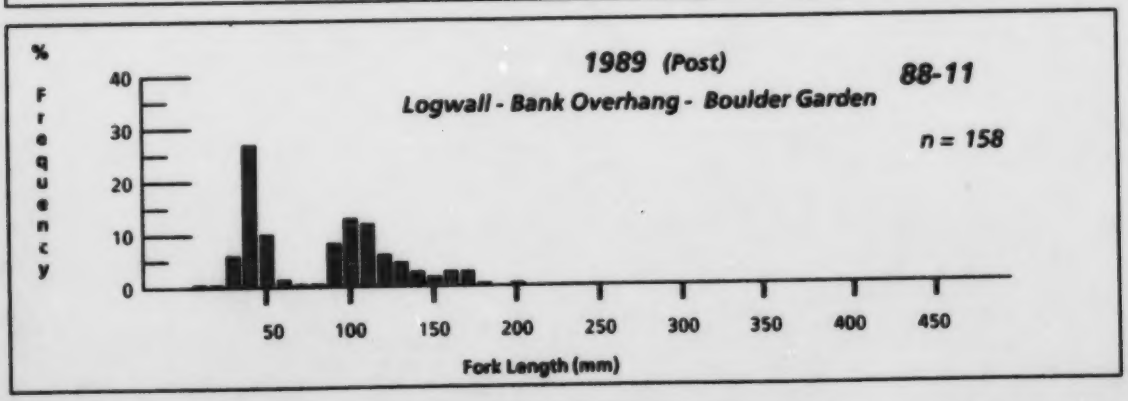


Figure 4.1 Continued.

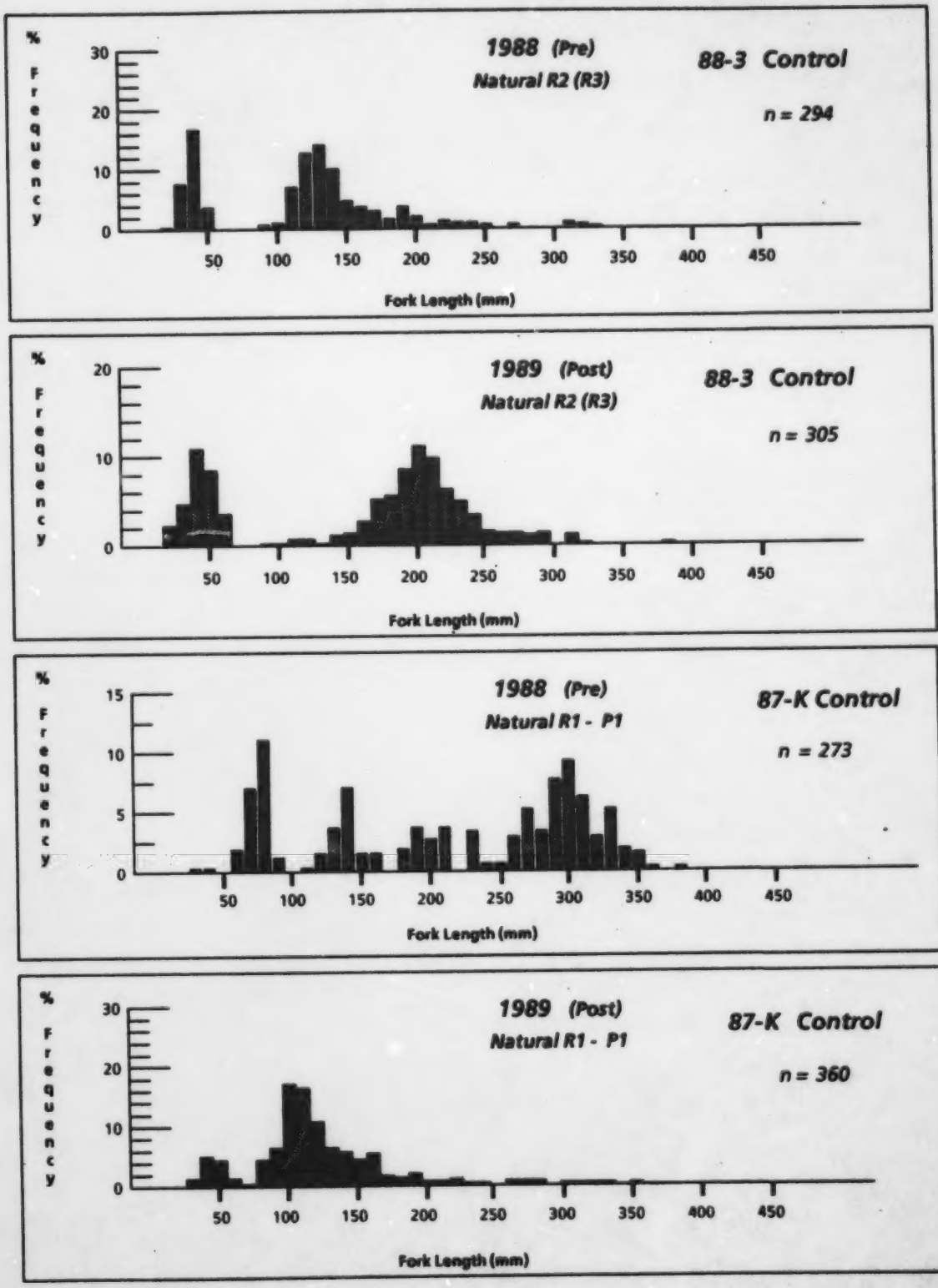


Figure 4.1 Concluded.

Sites 88-7,and 88-9 (Natural R3 to V-weir)

Sites 88-7 and 88-9 were upgraded from shallow run habitat (i.e., R3) to deep-pool/run habitat (i.e., R1/P1) through the construction of V-weirs. At year-1, no increase in the legal-size component of rainbow trout has occurred. This may be due to the fact that the habitat created is new and unstable. Alternatively, it may be due to the higher flows experienced in 1989 (i.e., less reliance on deeper, higher quality holding areas).

Sites 88-10 and 88-11 (Natural R3 to bank overhang/log wall)

Sites 88-10 and 88-11 were upgraded from shallow run habitat (R3) to excavated bank runs (R2) with associated overhang and boulder cover. As was the case with the previous sites, after year-1 no increase in the target legal-size component of rainbow trout has occurred. Again this may have resulted from the new (biologically speaking) and unstable nature and instability of the habitat.

Sites 88-3 and 87-K

Sites 88-3 and 87-K are long-term control habitats and as such were not modified. At site 88-3 (R2(R3) habitat) the length-frequency distribution of rainbow trout did not change appreciably between 1988 and 1989. In contrast, at site 87-K (R1/P1 habitat) a marked reduction of the larger size classes occurred from 1988 to 1989. This may have been due to the differences in flows between years (i.e., low flows in 1988 resulted in concentration of larger fish in high quality holding areas). It may also have been due to the recent addition of new habitats created in the area by the mitigation program.

4.3.2 Mountain Whitefish

The size distribution of mountain whitefish encountered at the eight population sites during the 1988 pre-enhancement and 1989 post-enhancement sampling program is illustrated in Figure 4.2. The raw data for the length-frequency distribution analyses is provided in Appendix B, Table B2.

4.4 POPULATION ESTIMATES (DENSITY AND BIOMASS)

4.4.1 Rainbow Trout

Population estimates, using a multi-pass removal-depletion method were developed at eight sites. Sites ranged from 49 to 143 m in length. Population density values (standardized to number fish/100 m) were generated for young-of-the-year, juveniles, and legal-sized rainbow trout (Table 4.3). Estimates for biomass (reported in kg/ha) are presented in Table 4.4. Population estimates developed for pre-enhanced (1988) and post-enhanced (1989) conditions are compared in Table 4.5 and

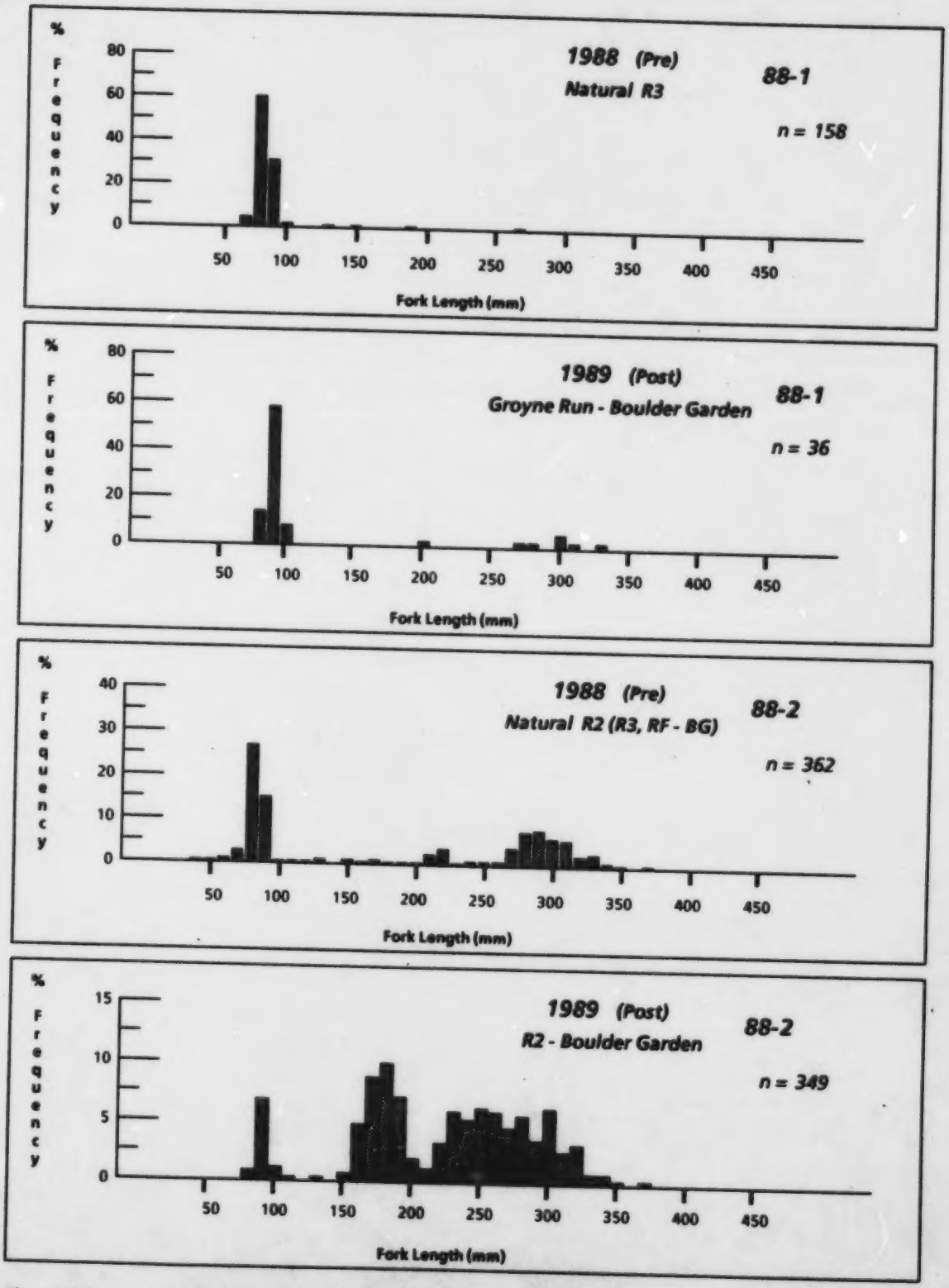
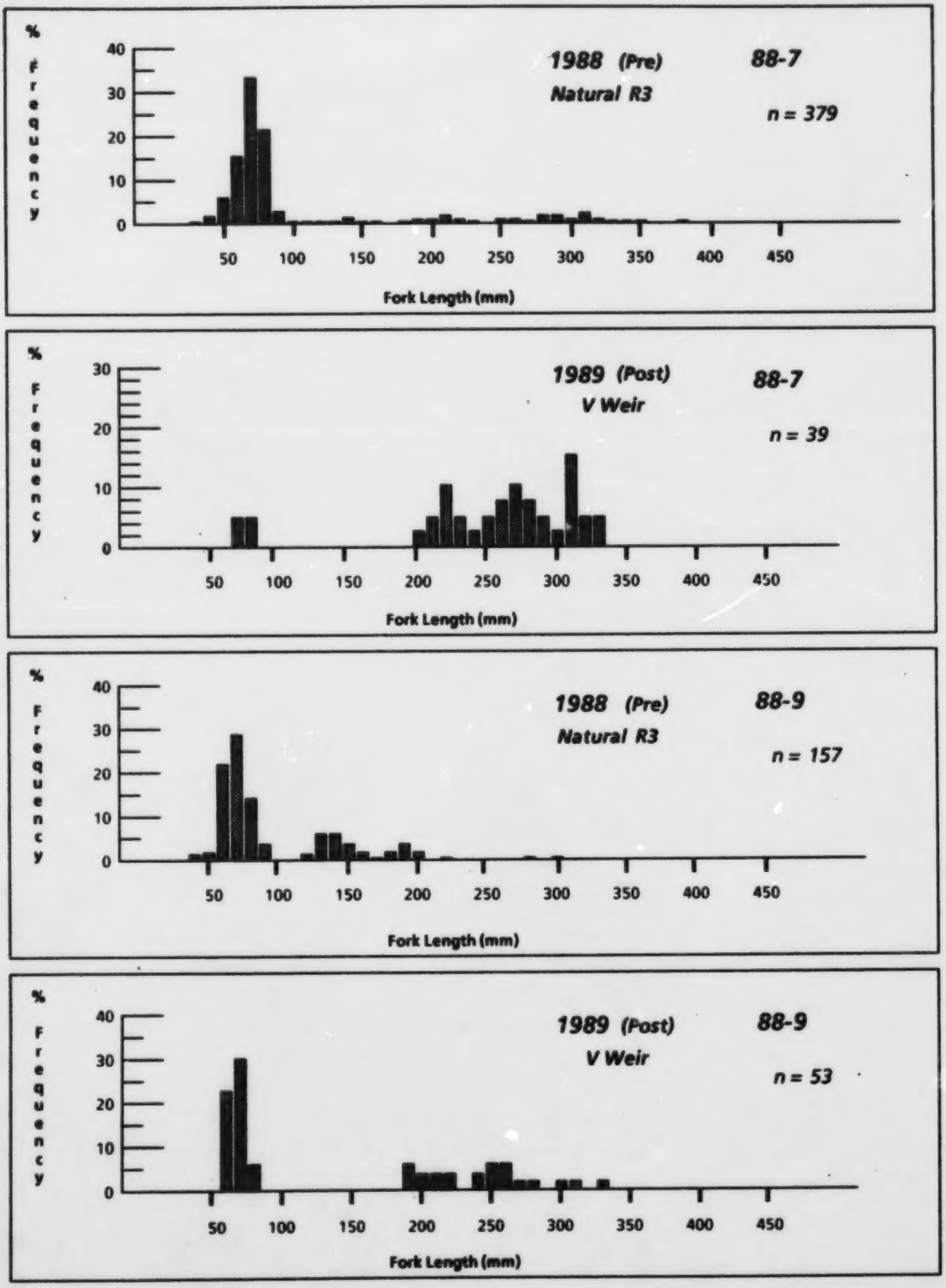


Figure 4.2 Length-frequency distribution of mountain whitefish from enhanced and control sites on the Crowsnest River during 1988 and 1989, (pre and post-construction).



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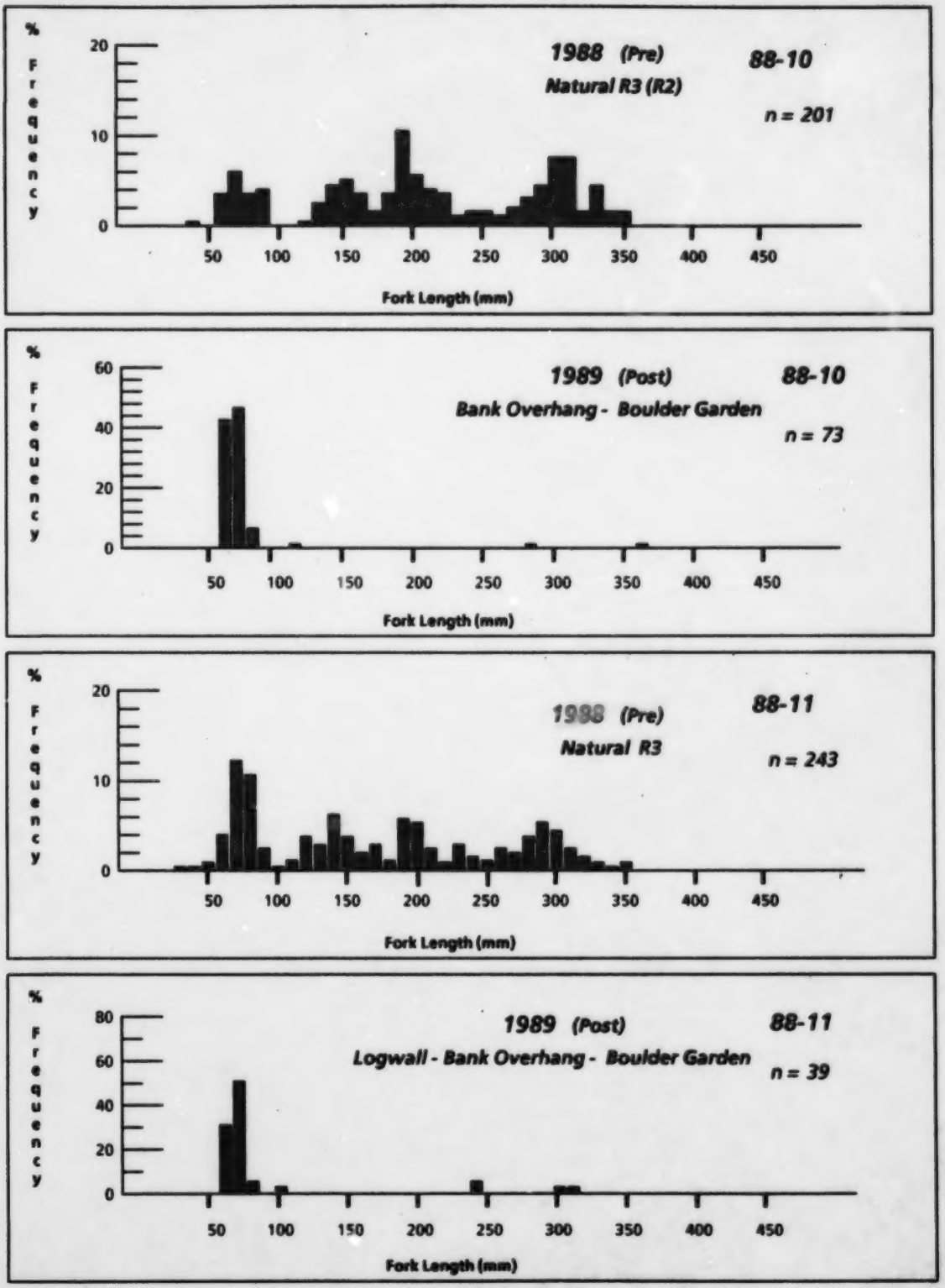

Figure 4.2 **Continued.**

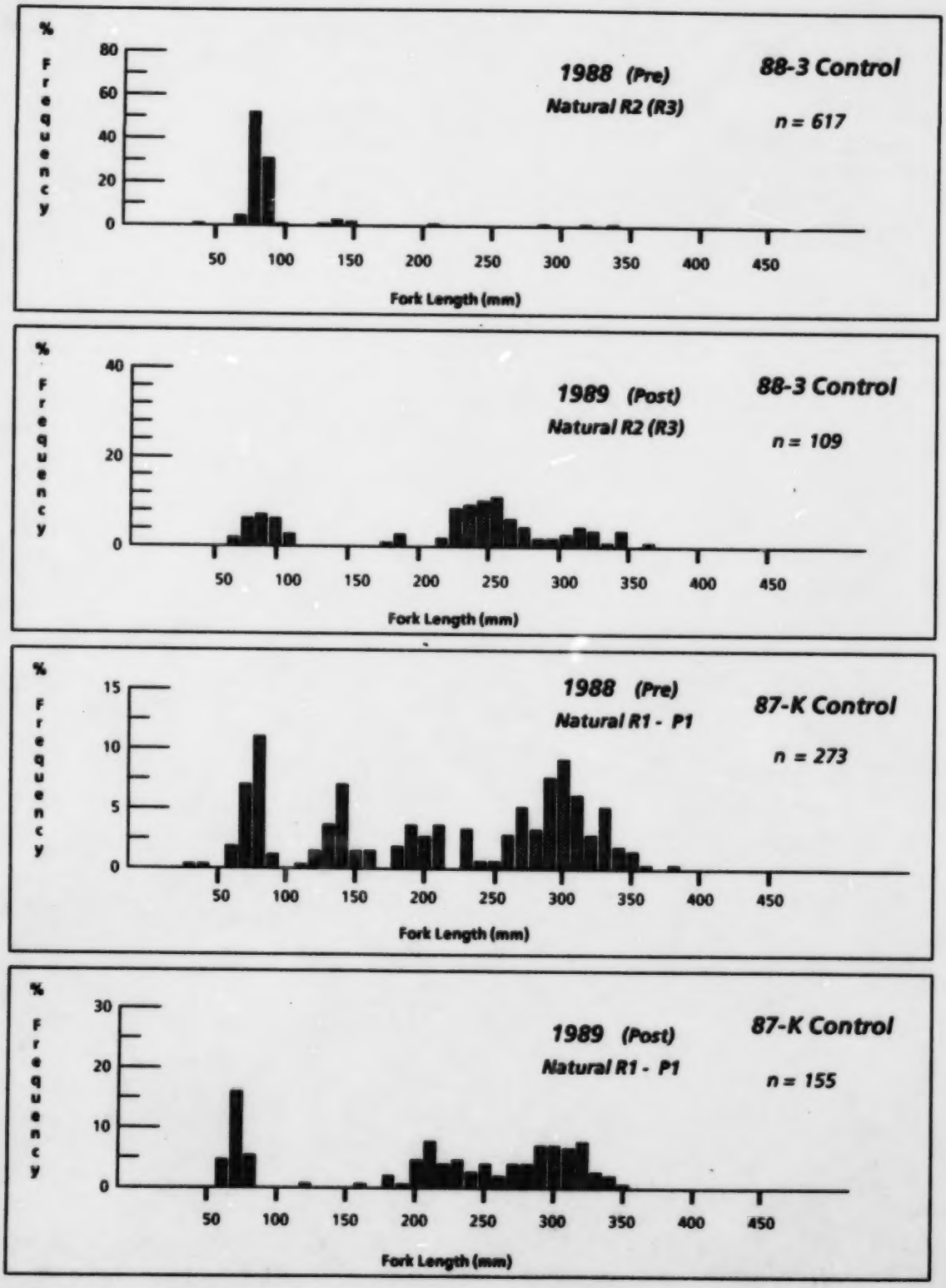

Figure 4.2 **Concluded.**

Figures 4.3-4.10. Non-standardized population estimates (density for actual section sampled) and raw data for individual removal-depletion runs are provided in Appendix B, Tables B2 and B3.

Table 4.3 Estimates of rainbow trout population density (standardized to number per 100 m) at enhanced and control sites on the Crowsnest River during 1989, (post-construction).

Enhancement Area	Site	Section Length (m)	SIZE-CLASS: Young-of-the-year (<80 mm) No. per 100 m	95% C.I.	Juveniles (80-253 mm) No. per 100 m	95% C.I.	Legal (≥254 mm) No. per 100 m	95% C.I.	All Size-Classes No. per 100 m	95% C.I.
Near Hillcrest	88-1	71	44	35-63	399	368-421	6[b]	N.A.[a]	446	408-472
	88-2	63	106	105-111	>1221[b]	N.C.[c]	38	38-40	3229	1363-4308
	88-3*	52	194	175-218	381	365-397	46	46-48	619	587-644
Near Frank	88-7	57	102	82-133	46	42-56	7	7-12	158	132-192
	88-9	49	108	92-136	241	208-277	7[b]	N.A.	361	314-403
	88-10	103	80	55-117	210	205-216	6	6-7	280	266-291
	88-11	143	57	50-67	67	60-76	0	-	125	110-138
	87-K*	65.5	72	69-80	499	463-524	18	18-20	591	550-617

[a]Not Applicable; confidence interval (C.I.) same as population estimate.
[b]Value given is actual catch; population estimate would be greater than catch (population estimate not calculable due to ascending or irregular catch progression).
[c]Not calculated.
*Control site.

Site 88-1 (Natural R3 to groyne run/boulder garden)

The density of y-o-y rainbow trout was noticeably lower under post-enhancement conditions in 1989 as compared to 1988 (i.e., 96 vs 44 fish/100 m, respectively). The numbers of y-o-y at the nearby control site (88-3) also was slightly lower suggesting the change at 88-1 may not entirely be related to the enhancement. In contrast, juveniles at site 88-1 were present in much larger numbers in 1989, compared to 1988 densities. This may be partly a response to the habitat upgrading, particularly since the numbers of juveniles was down slightly at the control site (88-3). The density of legal-sized fish remained unchanged, suggesting that the instream works have not appreciably increased its value as adult feeding/holding habitat, at least not by year-1. Numbers of legal-size rainbow trout showed a marked increase at site 88-3, the associated control site (i.e., 19 to 46 fish/100 m).

Site 88-2 (Natural R2 (R3, RF/BC) to R2/boulder garden)

At site 88-2, the numbers of y-o-y rainbow trout remained unchanged between 1988 and 1989. However, juveniles showed a large increase (i.e., 200 to 1221 fish/100 m). This increase may have resulted from the habitat upgrading, but also may reflect the presence of a strong year-class moving

Table 4.4 **Estimates of rainbow trout standing stock biomass (kg/ha) at enhanced and control sites on the Crowsnest River during 1989, (post-construction).**

Site	Sampled Area (ha)	SIZE-CLASS			
		Young-of-the-year (<80 mm) kg/ha ± 95% C.I.	Juveniles (80-253 mm) kg/ha ± 95% C.I.	Legal (≥ 254 mm) kg/ha ± 95% C.I.	All Sizes kg/ha ± 95% C.I.
88-1	0.120	0.5 ± 0.4	134.7 ± 15.1	8.0 ± 0.9	143.3 ± 15.2
88-2	0.093	1.4 ± 0.1	510.5 ± 21.6	82.0 ± 12.8	593.9 ± 25.1
88-3*	0.087	1.7 ± 0.3	230.3 ± 16.3	76.1 ± 13.0	308.1 ± 20.9
88-7	0.081	0.9 ± 0.3	11.1 ± 4.9	14.3 ± 10.4	26.3 ± 11.4
88-9	0.072	1.0 ± 0.3	63.5 ± 14.9	32.7 ± 11.9	97.3 ± 19.2
88-10	0.158	0.8 ± 0.4	37.5 ± 4.3	13.3 ± 4.8	51.7 ± 6.4
88-11	0.169	0.7 ± 0.1	13.8 ± 3.8	0	14.4 ± 2.8
87-K*	0.082	0.9 ± 0.2	118.2 ± 13.6	41.9 ± 6.5	161.1 ± 15.1

*Control site.

into the juvenile size range. Sampling in subsequent years will determine whether or not the density of legal trout shows an equivalent increase. The numbers of legal rainbow trout was down from 46 to 38 fish/100 m in 1989. The reason for this decrease is unknown at this time.

Site 88-3 (Control, natural R2 (R3))

Overall the rainbow trout population density at Site 88-3 was lower in 1989 than in 1988, although biomass increased for the same period. This was probably due to the higher numbers of legal trout encountered in 1989 which would have caused a subsequent increase in the biomass at the site. The higher flows experienced in 1989 increased the depth and cover quality of the site, factors that may have influenced the use of the area by larger fish.

Site 88-7 (natural R3, to V-weir)

Site 88-7 was upgraded from a R3 habitat to a deeper, high quality habitat through use of a V-weir structure. The year-1 data indicate a drop in density and biomass of juveniles and legal-size trout. Numbers of y-o-y fish remained essentially unchanged. This was somewhat surprising since the newly created habitat appeared well suited for use by legal-size rainbow trout. It may be that the habitat at year-1 is still relatively unstable (on a microhabitat level). It may well take several years for enhanced habitats in the upper Crowsnest River to reach the desired carrying capacity. The

Table 4.5 Estimates of rainbow trout population density (standardized to number per 100 m) at enhanced and control sites on the Crowsnest River during 1988 and 1989, (pre and post-construction).

Site	Description	POPULATION ESTIMATES (95% Confidence Interval)							
		Young-of-the-year (<80 mm)		Juveniles (80-253 mm)		Legal (≥ 254 mm)		All Size-Classes	
		1988 (Pre)	1989 (Post)	1988 (Pre)	1989 (Post)	1988 (Pre)	1989 (Post)	1988 (Pre)	1989 (Post)
	Hillcrest								
88-1	Groyne run/boulder garden	96(80-118)	44(35-63)	230(166-293)	399(368-421)	6(6-8)	6[a](N.A.)[c]	332(269-396)	446(408-472)
88-2	Boulder garden	133(113-160)	106(105-111)	200(178-224)	1221[a](n.c.)[b]	46(46-48)	38(38-40)	378(346-410)	3229(1363-4308)
88-3	Control (Natural R2 (R3))	223(160-300)	194(175-218)	490(415-565)	381(365-397)	19(19-21)	46(46-48)	725(629-821)	619(587-644)
	Frank								
88-7	V Weir	105(100-116)	102(82-133)	381(377-388)	46(42-56)	21(N.A.)	7(7-12)	507(498-518)	158(132-192)
88-9	V Weir	107(103-115)	108(92-136)	281(281-284)	241(208-277)	4(N.A.)	7[a](N.A.)	391(388-397)	361(314-403)
88-10	Bank overhang/boulder garden	54(46-67)	80(55-117)	214(211-219)	210(205-216)	10(N.A.)	6(6-7)	274(267-282)	280(266-291)
88-11	Log wall/overhang/boulder garden	36(32-45)	57(50-67)	171(163-180)	67(60-76)	20(N.A.)	-	225(216-234)	125(110-138)
87-K	Control (Natural R1/P1)	186(153-223)	72(69-80)	623(600-646)	499(463-524)	44(44-47)	18(18-20)	846(814-878)	591(550-617)

[a]Value given is actual catch; population estimate would be greater than catch (population estimate not calculatable due to ascending or irregular catch progression).
[b]Not calculated.
[c]Not Applicable; confidence interval (C.I.) same as population estimate.

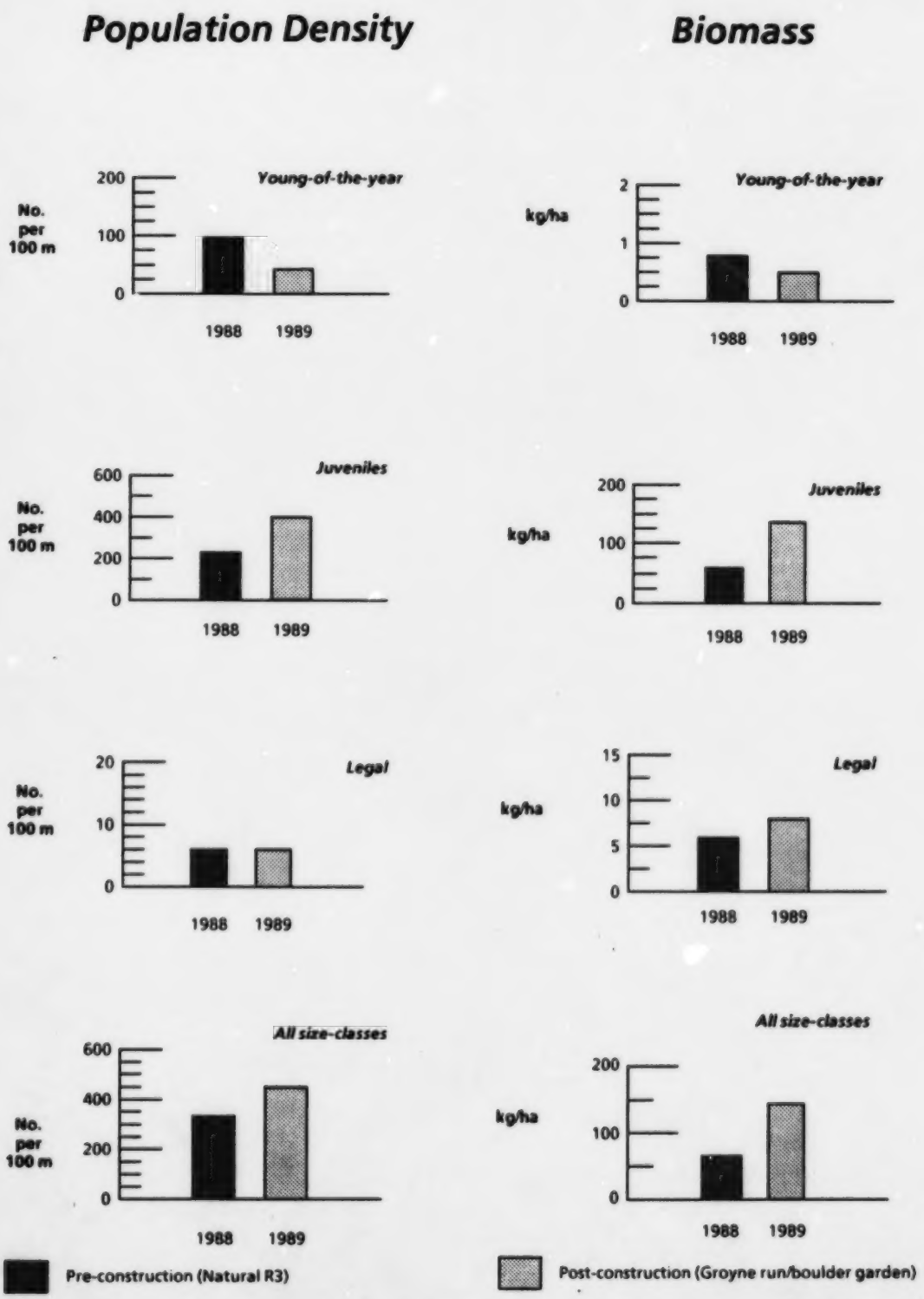

Figure 4.3 Estimates of rainbow trout population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-1 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

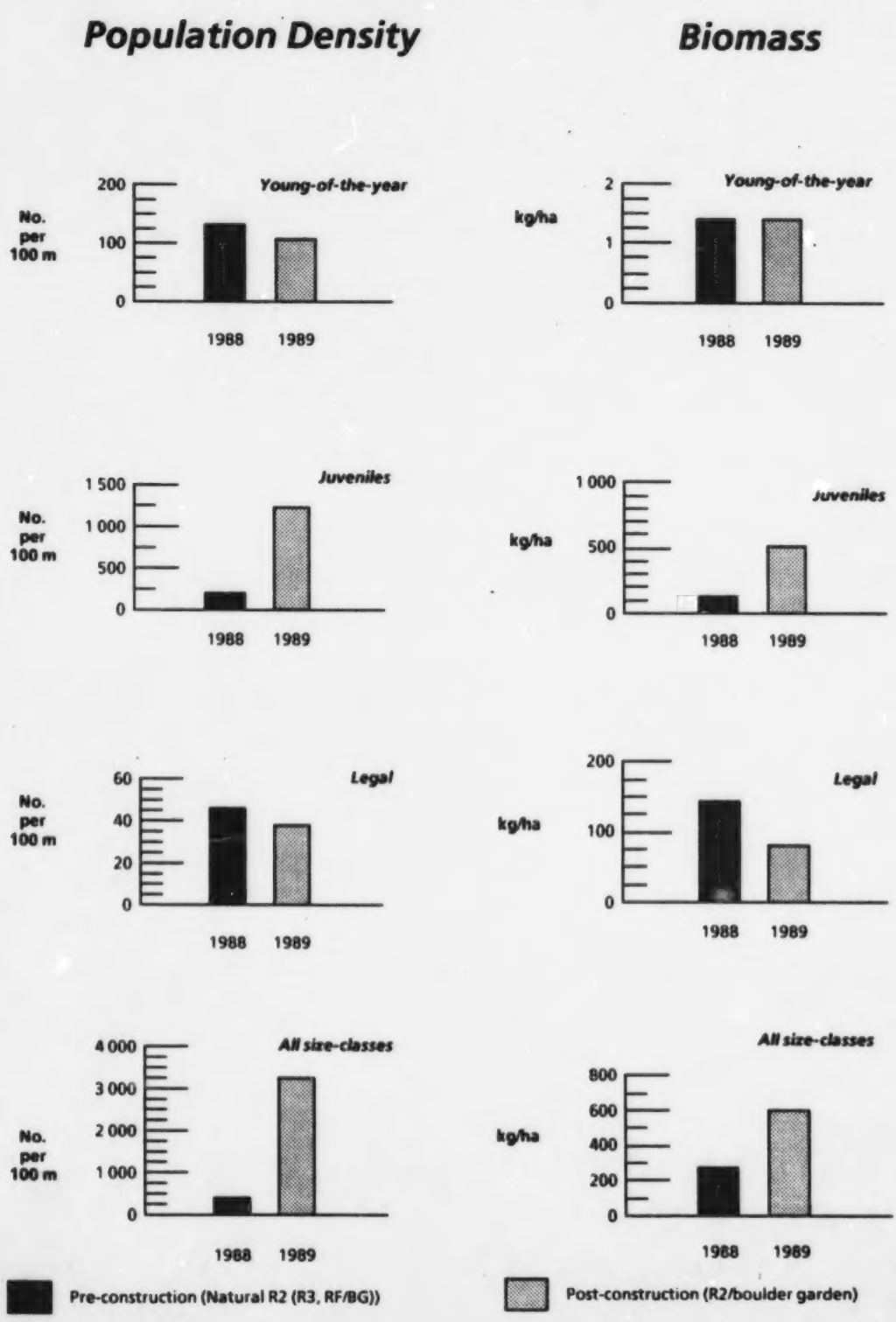

Figure 4.4 Estimates of rainbow trout population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-2 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

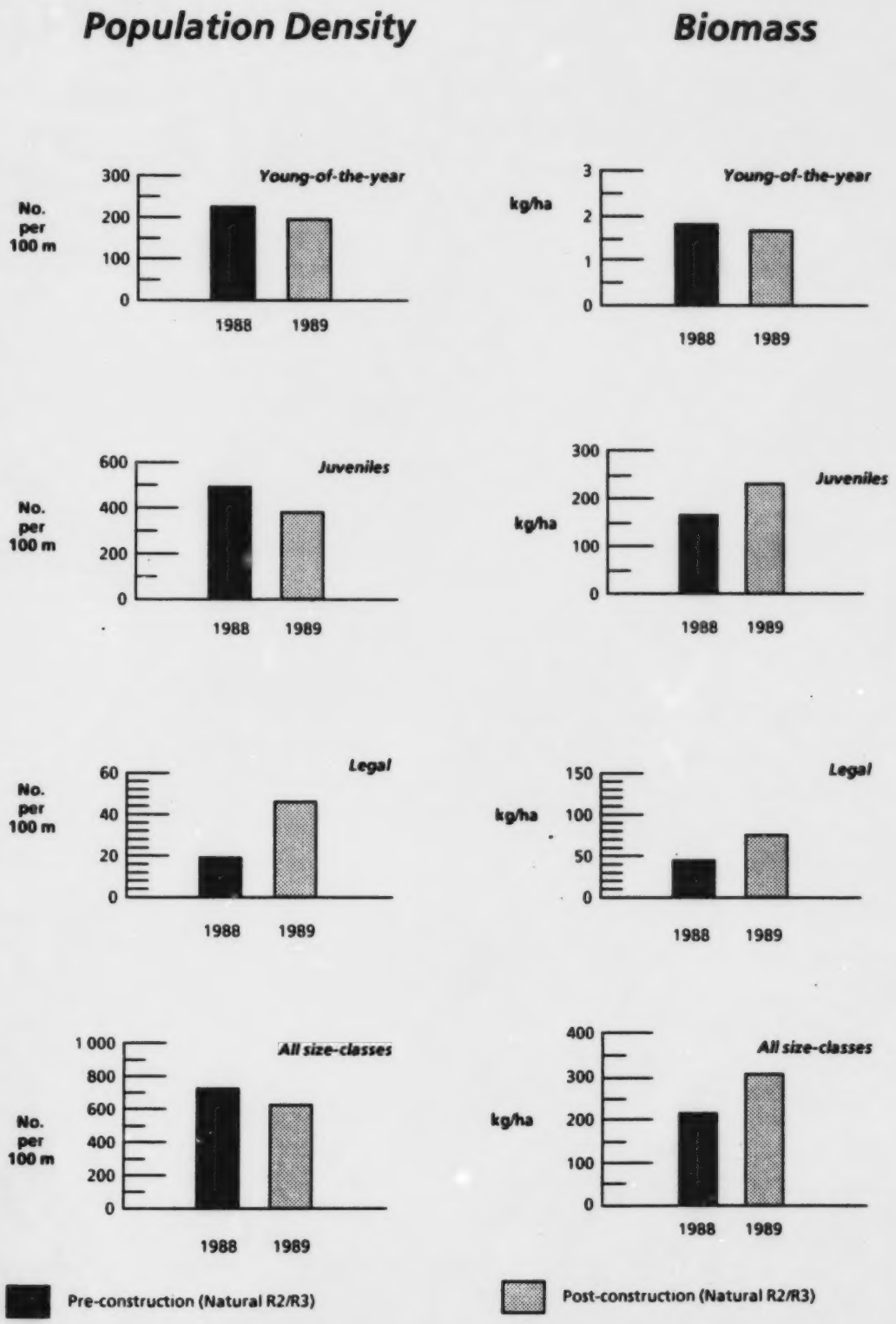

Figure 4.5 Estimates of rainbow trout population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-3 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

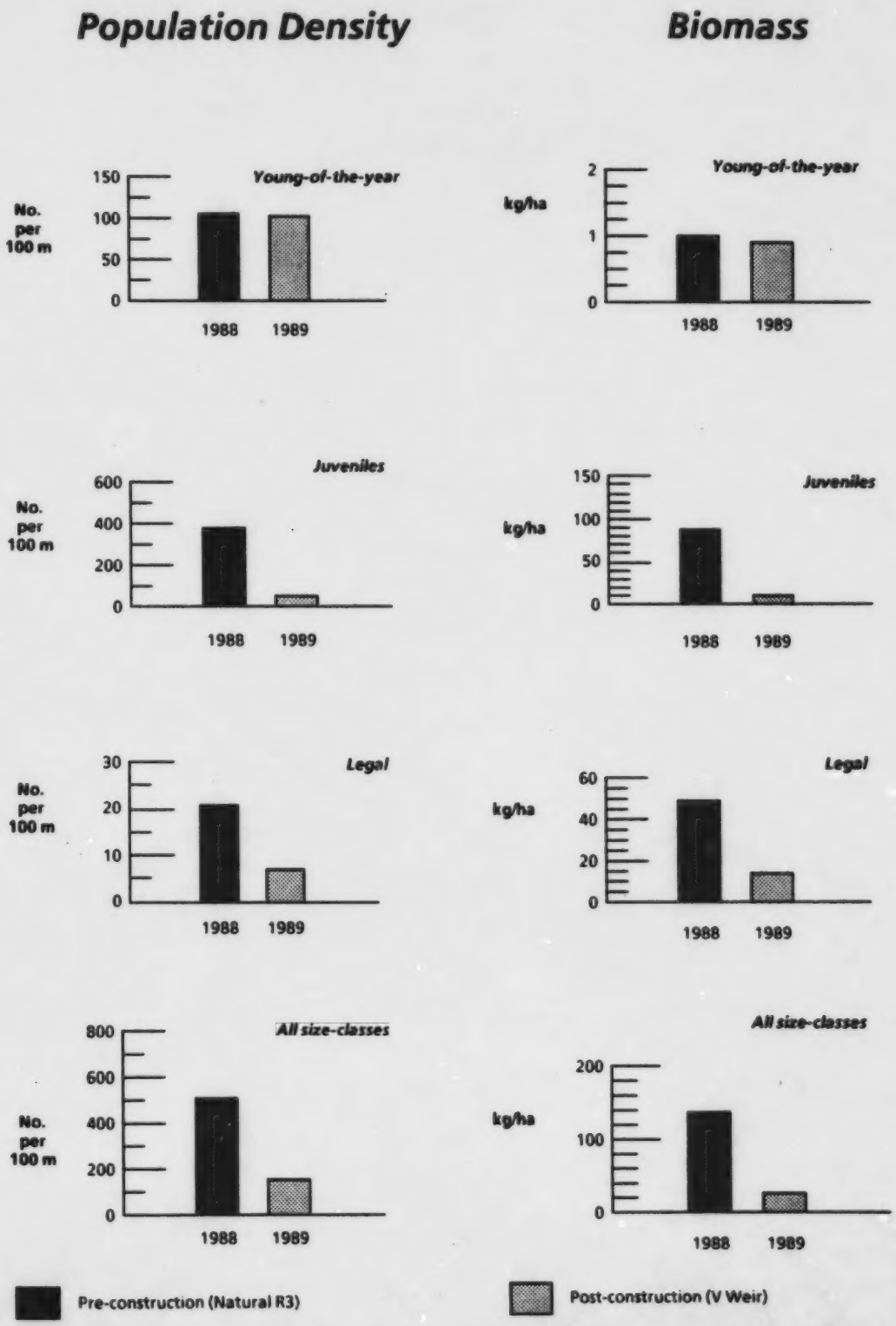

Figure 4.6 Estimates of rainbow trout population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-7 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

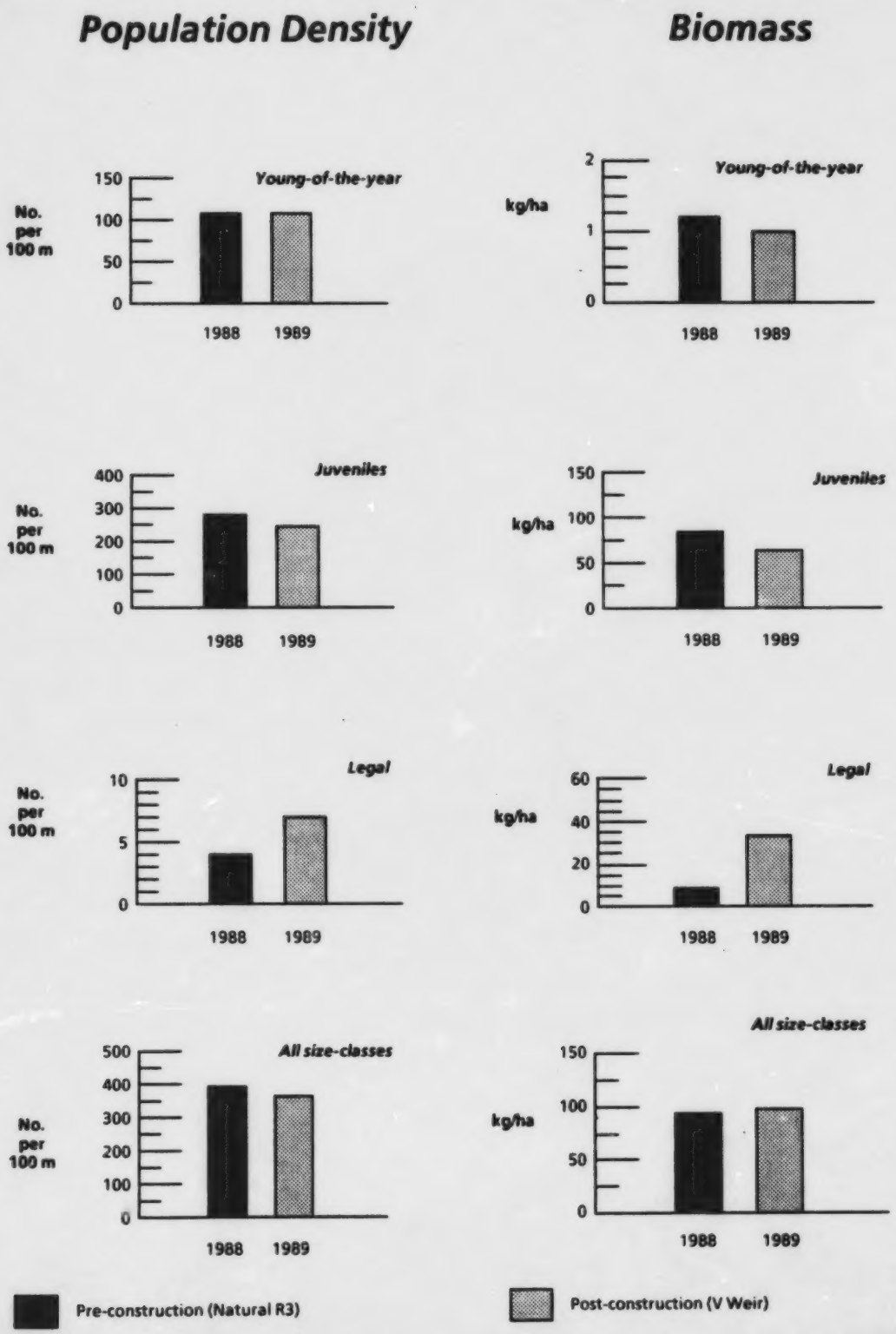

Figure 4.7 Estimates of rainbow trout population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-9 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

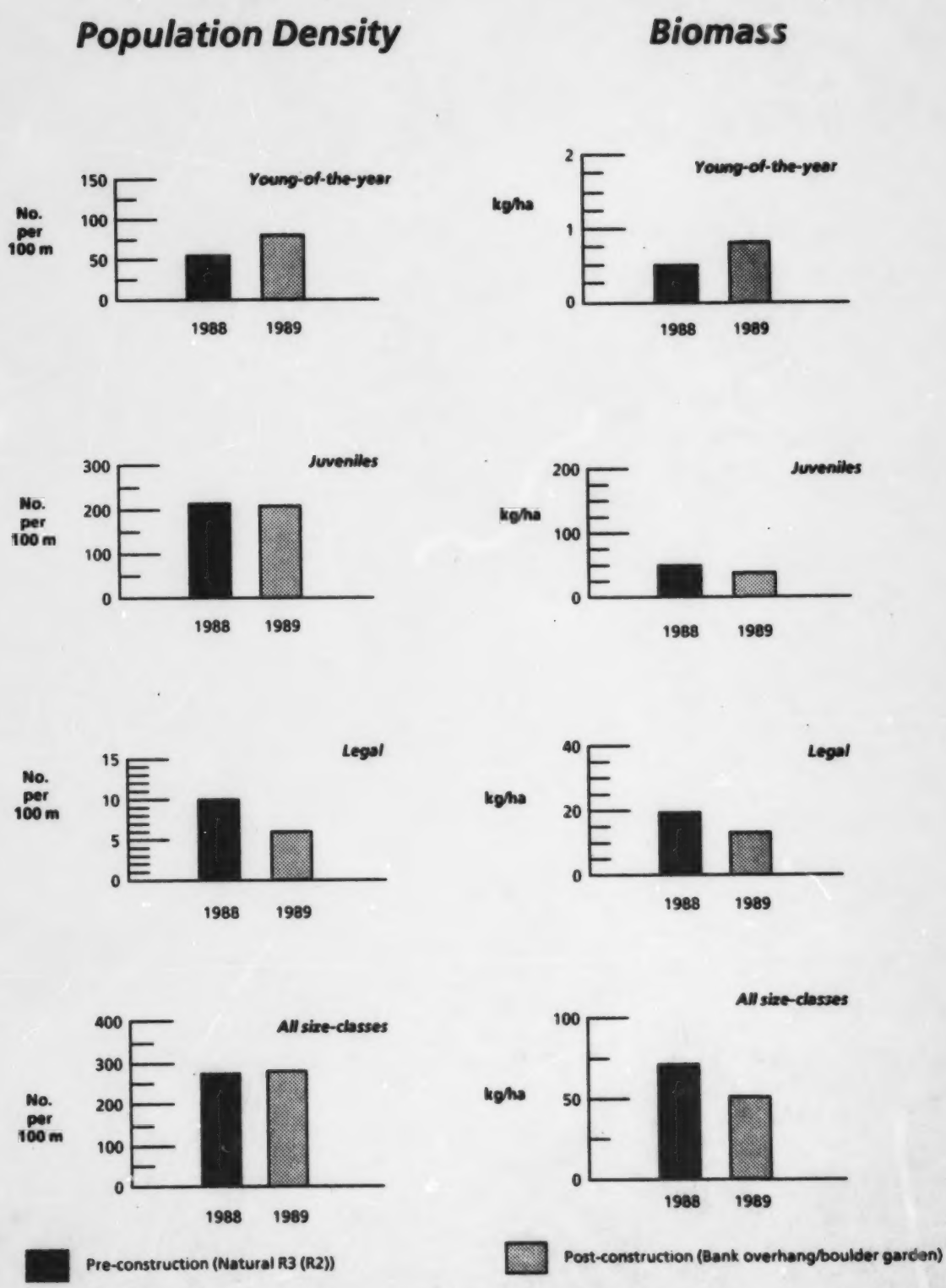

Figure 4.8 Estimates of rainbow trout population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-10 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

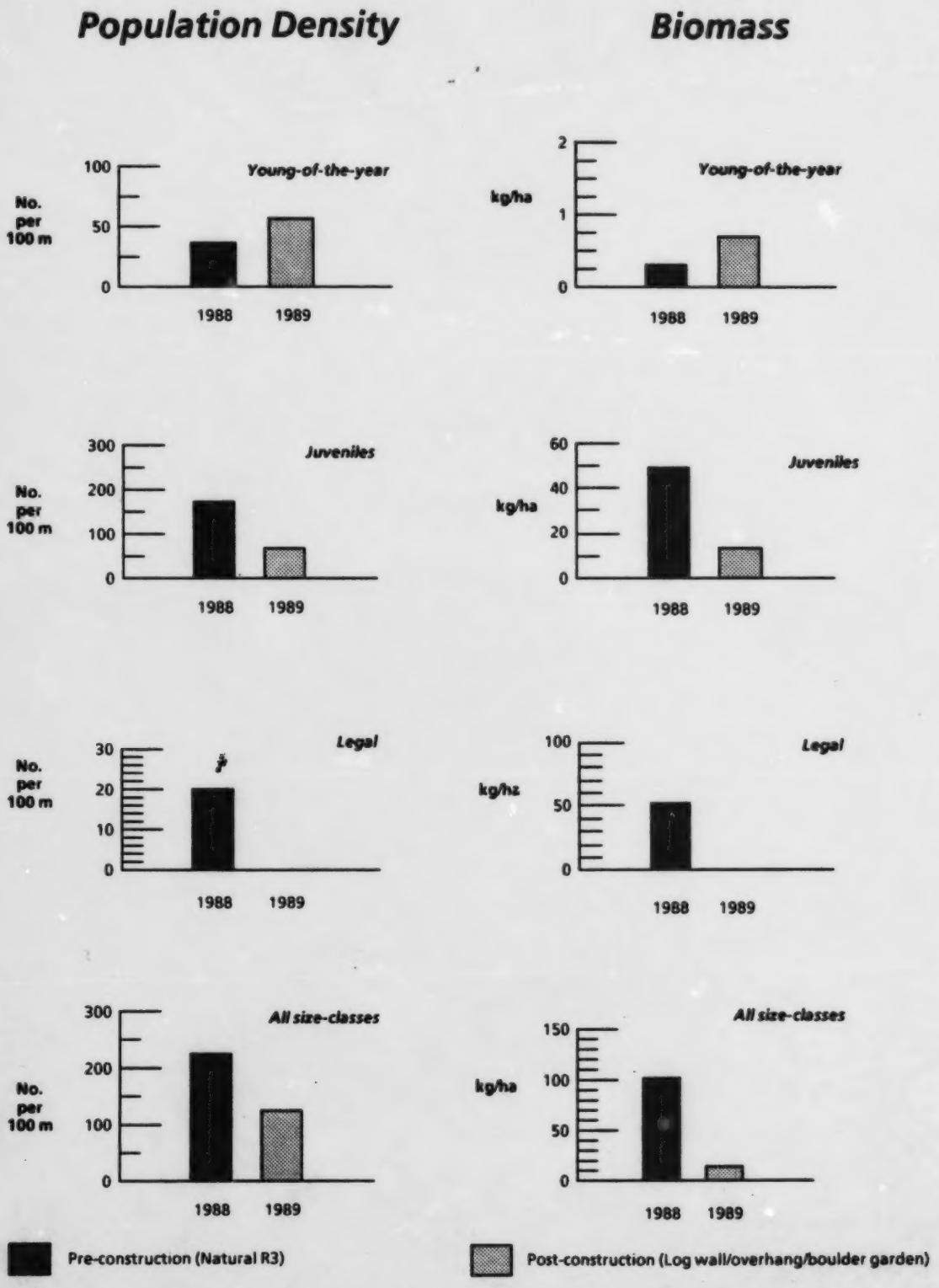

Figure 4.9 Estimates of rainbow trout population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-11 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

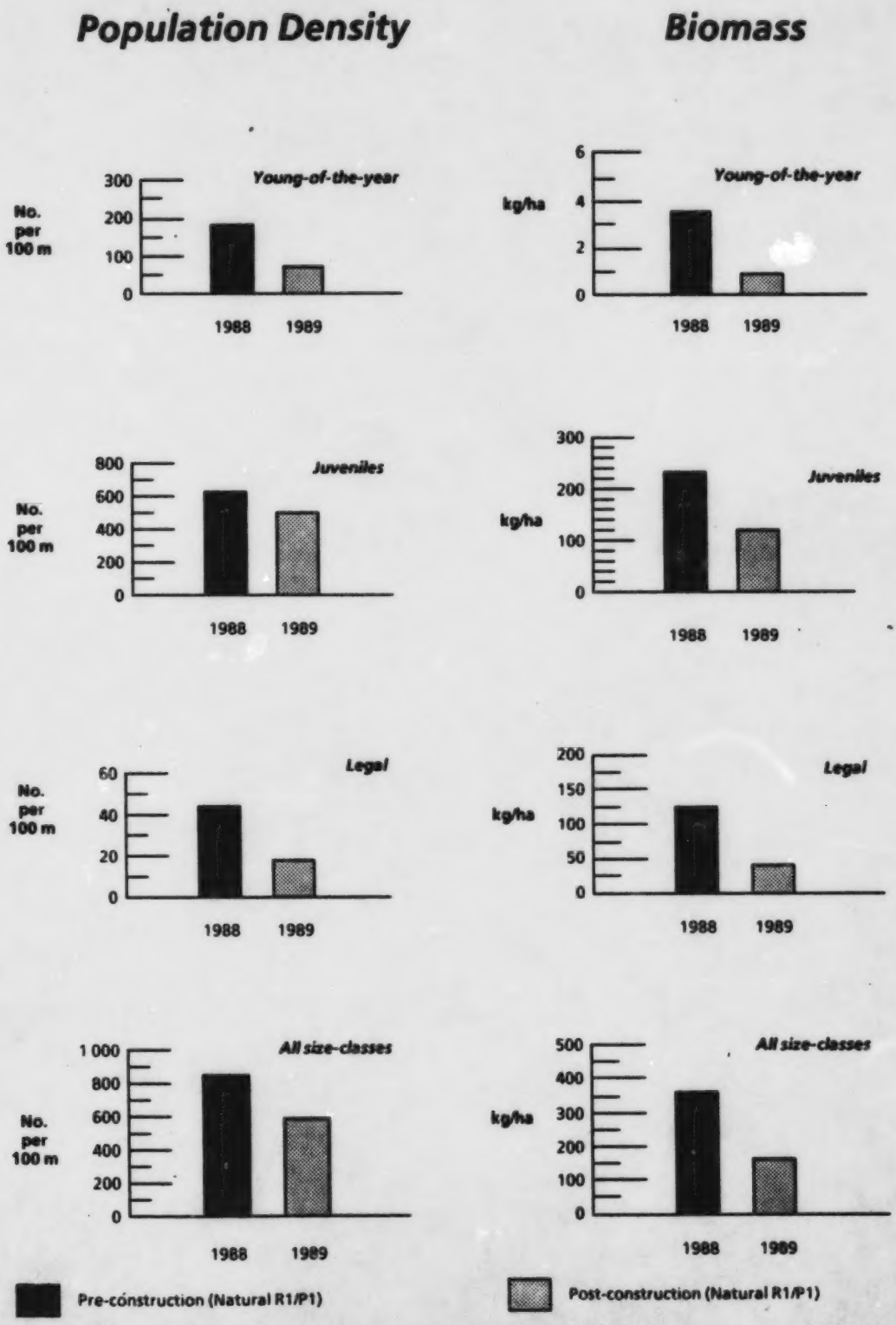

Figure 4.10 Estimates of rainbow trout population density (standardized to number per 100 m) and biomass (kg/ha) at Site 87-K on the Crowsnest River during 1988 and 1989, (pre and post-construction).

number of legal trout at nearby site 87-K, a natural high quality control (i.e., R1/P1 habitat) decreased dramatically between 1988 and 1989.

Site 88-9 (Natural R3 to V-weir)

At site 88-9, situated just upstream of Site 88-7, rainbow trout y-o-y and juvenile densities remained similar in 1989 compared to 1988. The density and biomass of legal-size rainbow trout, however, exhibited a slight increase between years. In 1989, both V-weir sites (88-7 and 88-9) had similar densities of legal-size trout (i.e., 7 fish/100 m). This is in comparison to 18 legal-size trout/100 m recorded at the natural R1/P1 control site (87-K) in 1989. Apparently the use of enhanced sites by legal-size trout after year-1 is still considerably lower than use of natural high quality habitats.

Site 88-10 (Natural R3 to bank overhang/boulder garden)

No major changes in population density or biomass of all size-classes of rainbow trout occurred at this site between 1988 and 1989. The density of legal trout remained fairly low (i.e., 6 fish/100 m) in comparison to the natural high quality control (18 fish/100 m) at Site 87-K.

Site 88-11 (Natural R3 to log wall/overhang/boulder garden)

The population response at this site after one year was disappointing. While y-o-y rainbow trout densities increased slightly from 1988 to 1989, both juveniles and legal trout densities decreased substantially. One possible explanation is that the habitat is still relatively unstable and will require several years to reach the desired carrying capacity. Further monitoring will be required to determine the ultimate success of this and other structures.

Site 87-K (Control, Natural R1/P1)

At this site, the density and biomass of all size-classes of rainbow trout declined from 1988 to 1989. As previously suggested, one possible reason for the reduced density and biomass of legal-size trout may be due to the difference in flows between years. Low flows in 1988 may have resulted in a concentration of adults in deeper, higher quality habitats.

4.4.2 Mountain Whitefish

Population estimates (standardized density and biomass values) for mountain whitefish are presented in Tables 4.6-4.8 and Figures 4.11-4.18. Non-standardized estimates (density for actual section sampled) and raw data for individual removal-depletion runs is provided in Appendix E, Tables E2 and E3.

Table 4.6 Estimates of mountain whitefish population density (standardized to number per 100 m) at enhanced and control sites on the Crowsnest River during 1989, (post-construction).

Enhancement Area	Site	Section Length (m)	SIZE-CLASS							
			Young-of-the-year (<120 mm)		Juveniles (120-253 mm)		Adult (≥254 mm)		All Size-Classes	
			No. per 100 m	95% C.I.	No. per 100 m	95% C.I.	No. per 100 m	95% C.I.	No. per 100 m	95% C.I.
Near Hillcrest	88-1	71	204	41-1356	0	-	8	8-11	254	51-1508
	88-2	63	50	50-51	1429	286-4453	267	217-311	884	554-1095
	88-3*	52	60	52-78	85	85-88	73	73-75	221	215-231
Near Frank	88-7	57	7	7-10	88	18-943	219	44-1513	342	68-1952
	88-9	49	316	63-2091	24	24-26	20	20-22	541	108-2711
	88-10	103	98	N.A.[a]	0	-	0	-	100	N.A.
	88-11	143	36	24-59	1	1-11	1	1-11	43	27-74
	87-K*	65.5	66	61-76	72	72-74	104	104-106	240	237-246

[a]Not Applicable; confidence interval (C.I.) same as population estimate.
*Control site.

Table 4.7 Estimates of mountain whitefish standing stock biomass (kg/ha) at enhanced and control sites on the Crowsnest River during 1989 (post-construction).

Site	Sampled Area (ha)	SIZE-CLASS			
		Young-of-the-year (<80 mm) kg/ha ± 95% C.I.	Juveniles (80-253 mm) kg/ha ± 95% C.I.	Adult (≥ 254 mm) kg/ha ± 95% C.I.	All Sizes kg/ha ± 95% C.I.
88-1	0.120	1.6 ± 0.1	0.8 ± n.a.[a]	15.6 ± 5.5	18.0 ± 5.5
88-2	0.093	2.8 ± 0.3	197.4 ± 14.1	565.5 ± 98.9	765.7 ± 99.9
88-3*	0.087	2.3 ± 0.8	80.3 ± 7.0	139.8 ± 14.5	222.4 ± 16.1
88-7	0.081	0.2 ± 0.1	9.9 ± 0.6	86.2 ± 8.3	96.5 ± 8.3
88-9	0.072	1.7 ± 0.2	21.0 ± 3.9	33.1 ± 7.1	55.9 ± 8.1
88-10	0.158	2.4 ± 0.3	0	14.1 ± 12.8	16.5 ± 12.8
88-11	0.169	1.2 ± 0.8	1.7 ± 1.9	3.3 ± 3.5	6.3 ± 4.1
87-K*	0.082	2.2 ± 0.4	69.5 ± 7.1	271.0 ± 19.3	342.7 ± 20.6

[a]Not applicable; confidence interval (C.I.) same as population estimate.
*Control site.

Table 4.8 Estimates of mountain whitefish population density (standardized to number per 100 m) at enhanced and control sites on the Crowsnest River during 1988 and 1989, (pre and post-construction).

Site	Description	POPULATION ESTIMATES (95% Confidence Interval)							
		Young-of-the-year (<120 mm)		Juveniles (120-253 mm)		Adult (≥254 mm)		All Size-Classes	
		1988 (Pre)	1989 (Post)	1988 (Pre)	1989 (Post)	1988 (Pre)	1989 (Post)	1988 (Pre)	1989 (Post)
	Hillcrest								
88-1	Groyne run/boulder garden	334(242-425)	204(41-1356)	4(4-6)	-	1(N.A.)[a]	8(8-11)	332(249-416)	254(51-1508)
88-2	Boulder garden	>260[b](N.C.)[c]	50(50-51)	129(70-254)	1429(286-4453)	243(230-257)	267(217-311)	919(679-1159)	884(554-1095)
88-3	Control (Natural R2 (R3))	1283(1186-1379)	60(52-78)	104(73-162)	85(85-88)	48(48-50)	73(73-75)	1414(1319-1508)	221(215-231)
	Frank								
88-7	V Weir	630(572-688)	7(7-10)	58(N.A.)	88(18-943)	70(N.A)	219(44-1513)	723(688-758)	342(68-1952)
88-9	V Weir	290(165-448)	316(63-2091)	63(N.A.)	24(24-26)	3(N.A.)	20(20-22)	269(235-303)	541(108-2711)
88-10	Bank overhang/boulder garden	57(42-88)	98 (N.A.)	113(113-116)	-	84(N.A.)	-	240(239-244)	100(N.A.)
88-11	Log wall/overhang/boulder garden	>70(N.C.)	36(24-59)	104(89-119)	1(1-11)	53(N.A.)	1(1-11)	244(222-265)	43(27-74)
87-K	Control (Natural R1/P1)	92(92-95)	66(61-76)	136(130-145)	72(72-74)	205(195-217)	104(104-106)	434(418-449)	240(237-246)

[a]Not Applicable; confidence interval (C.I.) same as population estimate.
[b]Value given is actual catch; population estimate would be greater than catch (population estimate not calculable due to ascending or irregular catch progression).
[c]Not calculated.

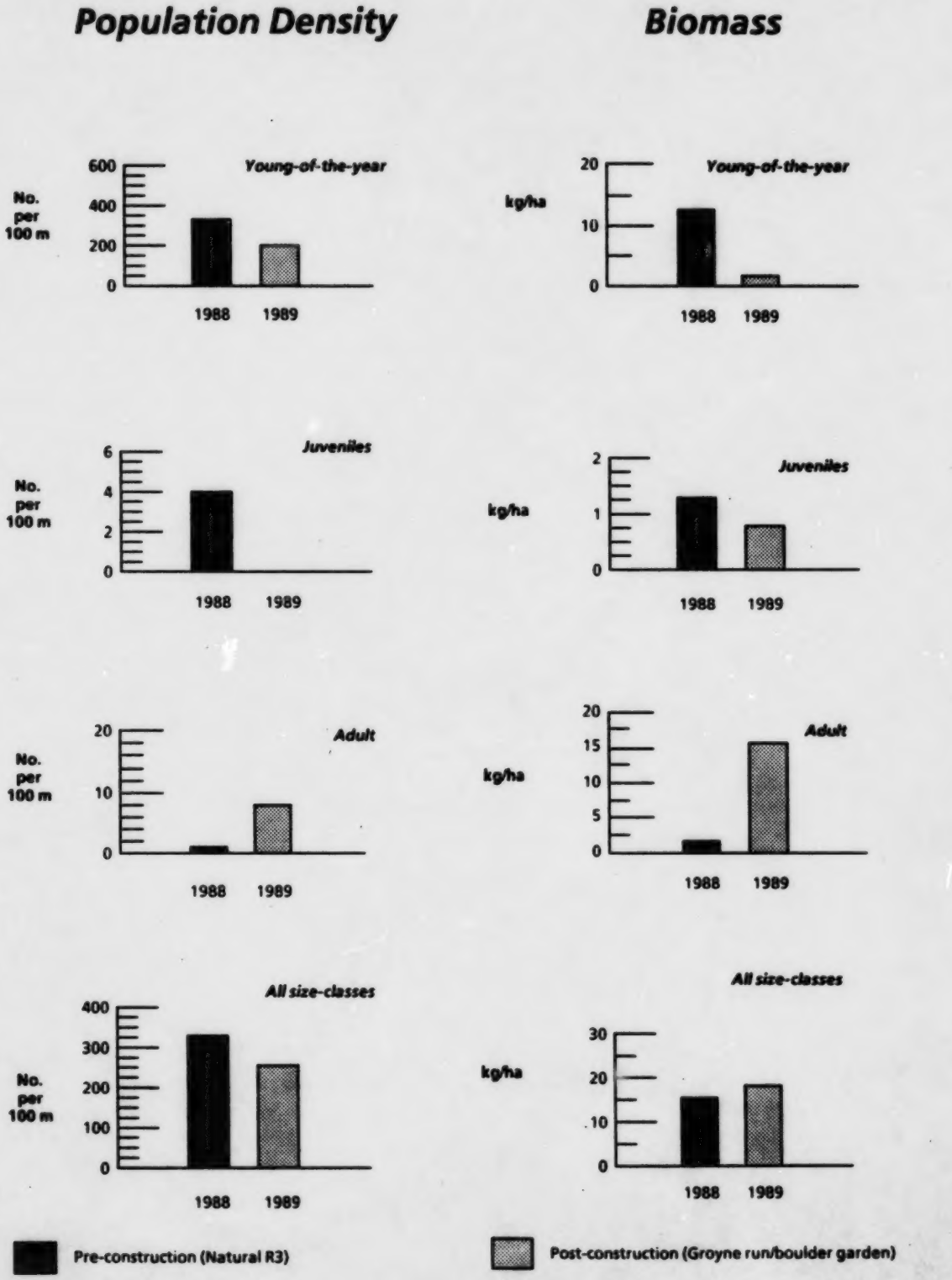

Figure 4.11 Estimates of mountain whitefish population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-1 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

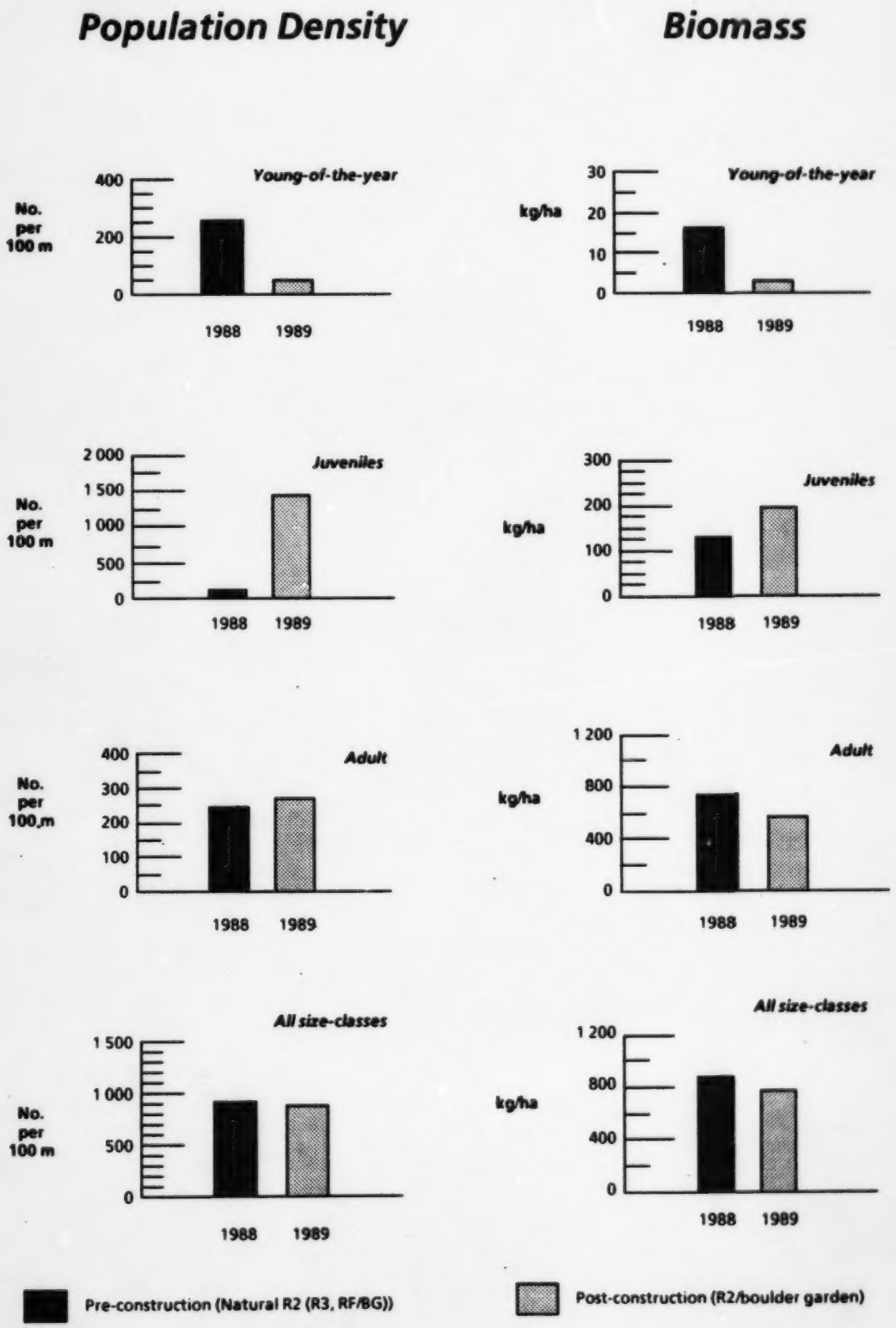

Figure 4.12 **Estimates of mountain whitefish population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-2 on the Crowsnest River during 1988 and 1989, (pre and post-construction).**

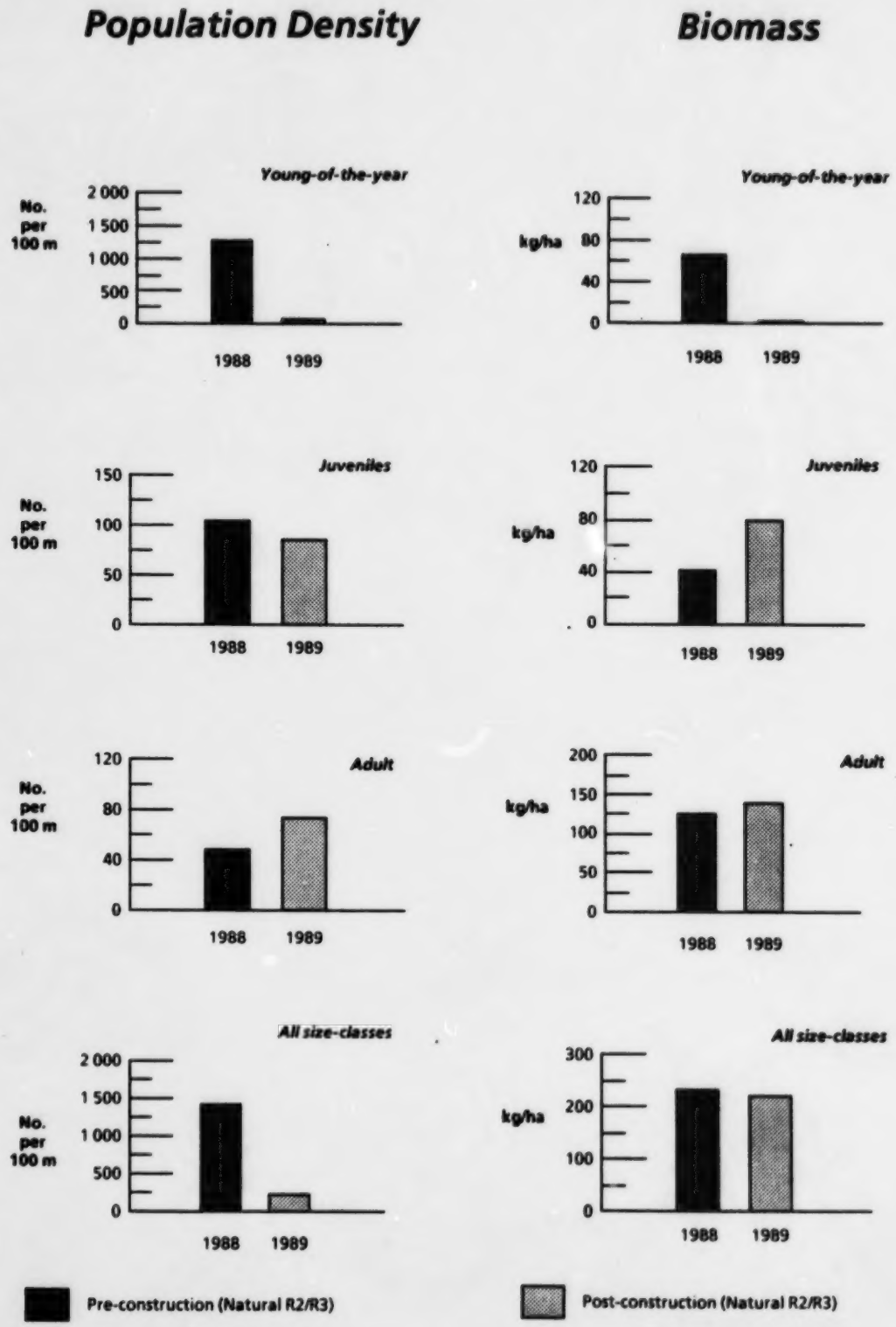

Figure 4.13 Estimates of mountain whitefish population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-3 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

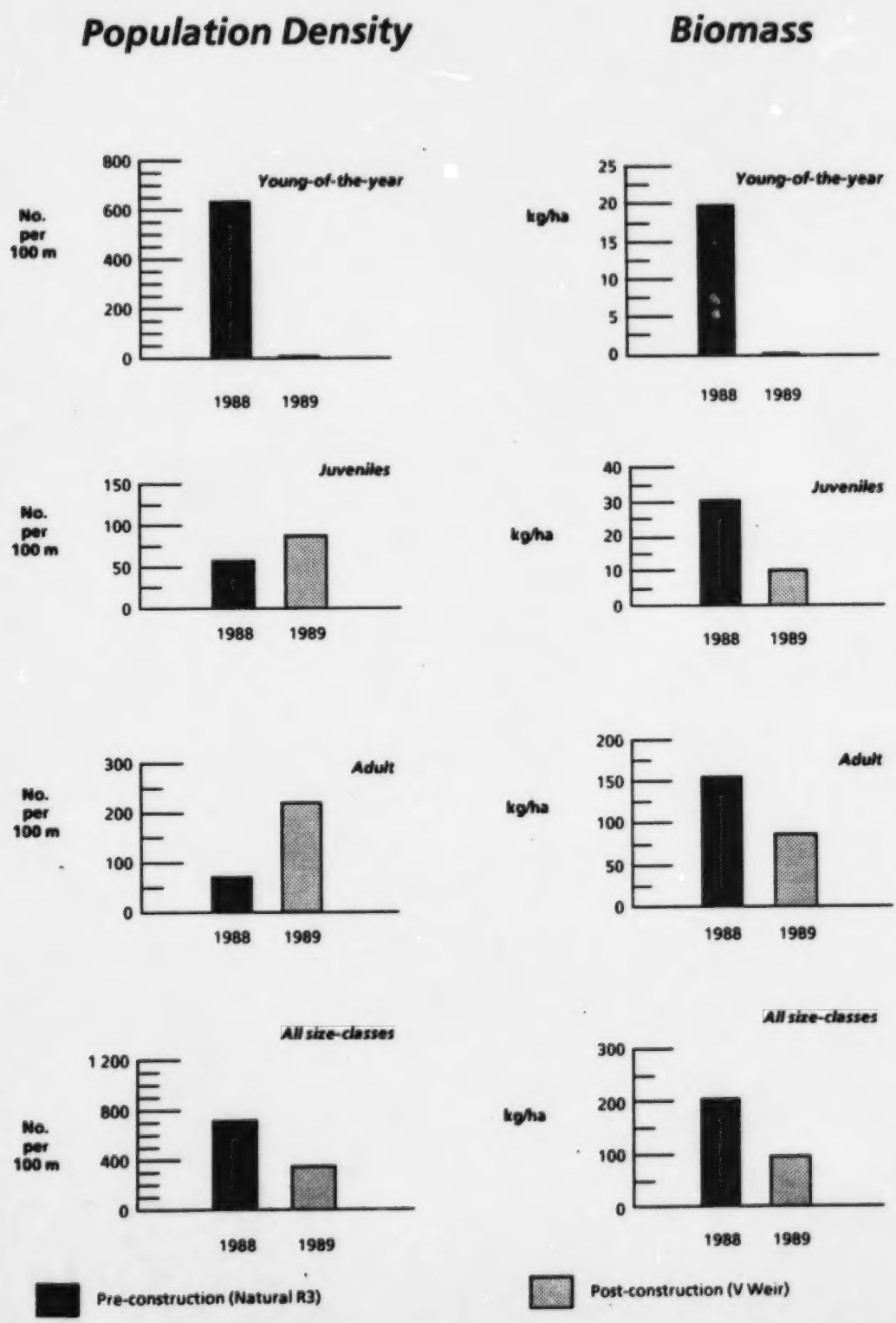

Figure 4.14 Estimates of mountain whitefish population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-7 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

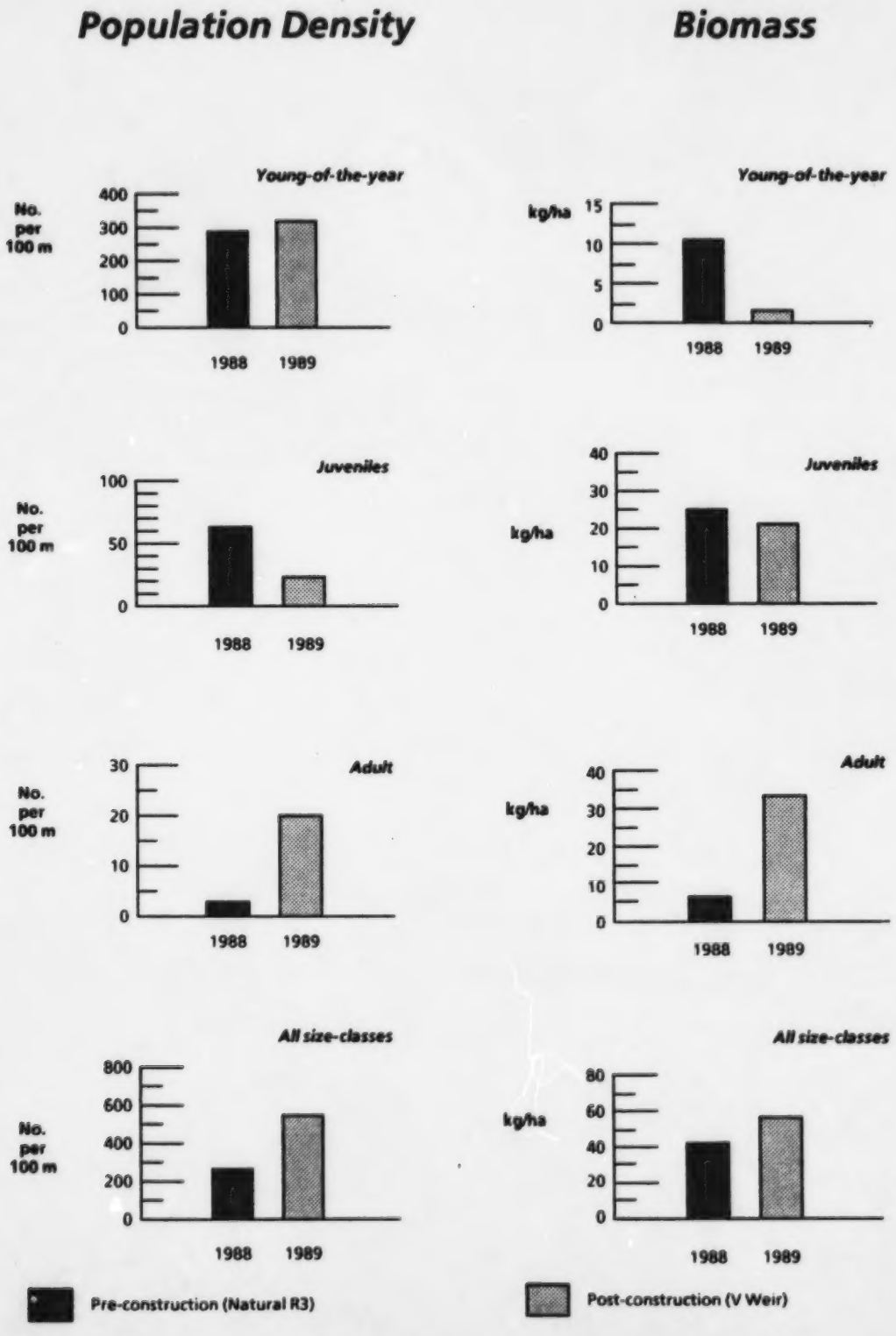

Figure 4.15 Estimates of mountain whitefish population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-9 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

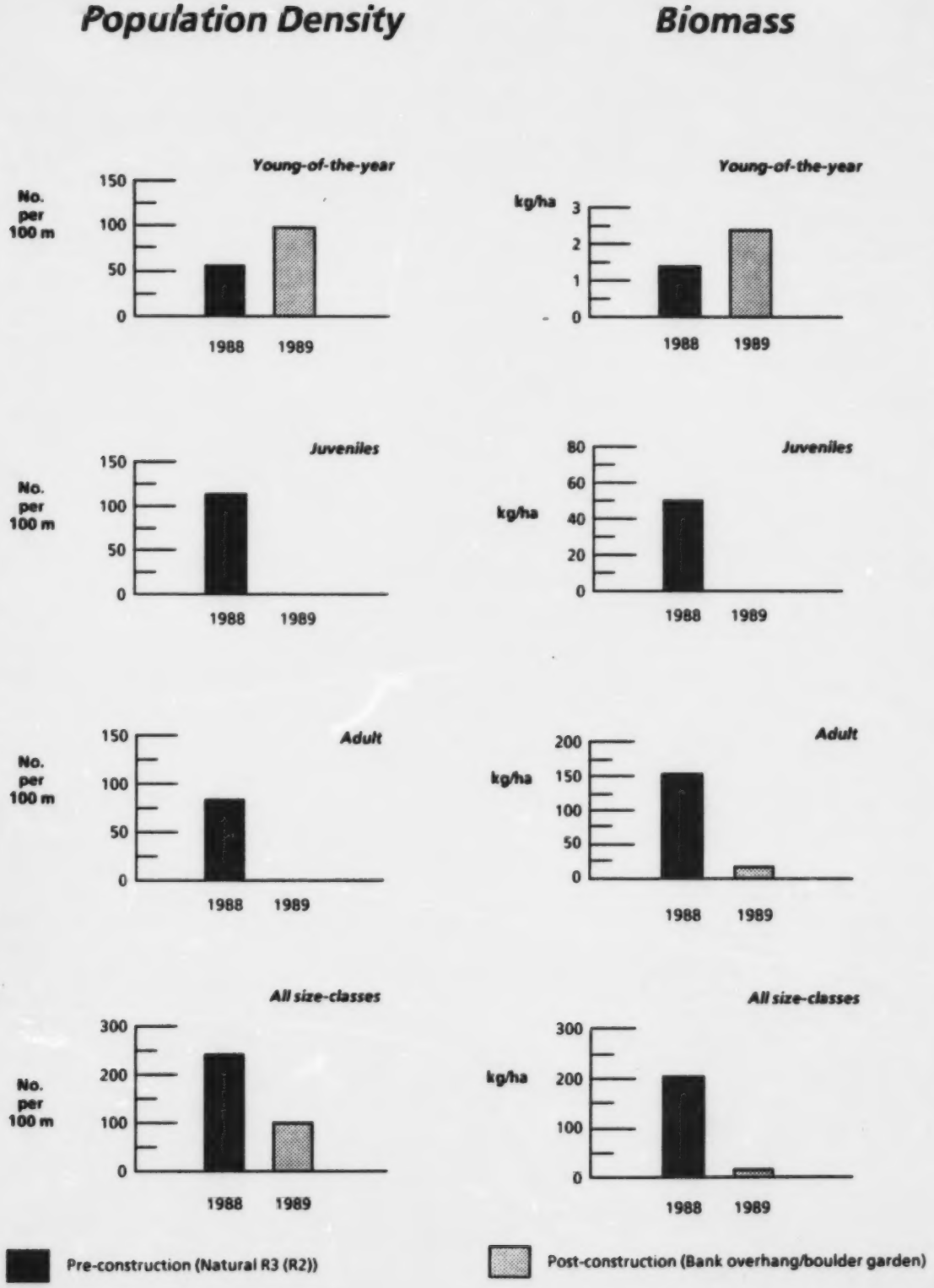

Figure 4.16 Estimates of mountain whitefish population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-10 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

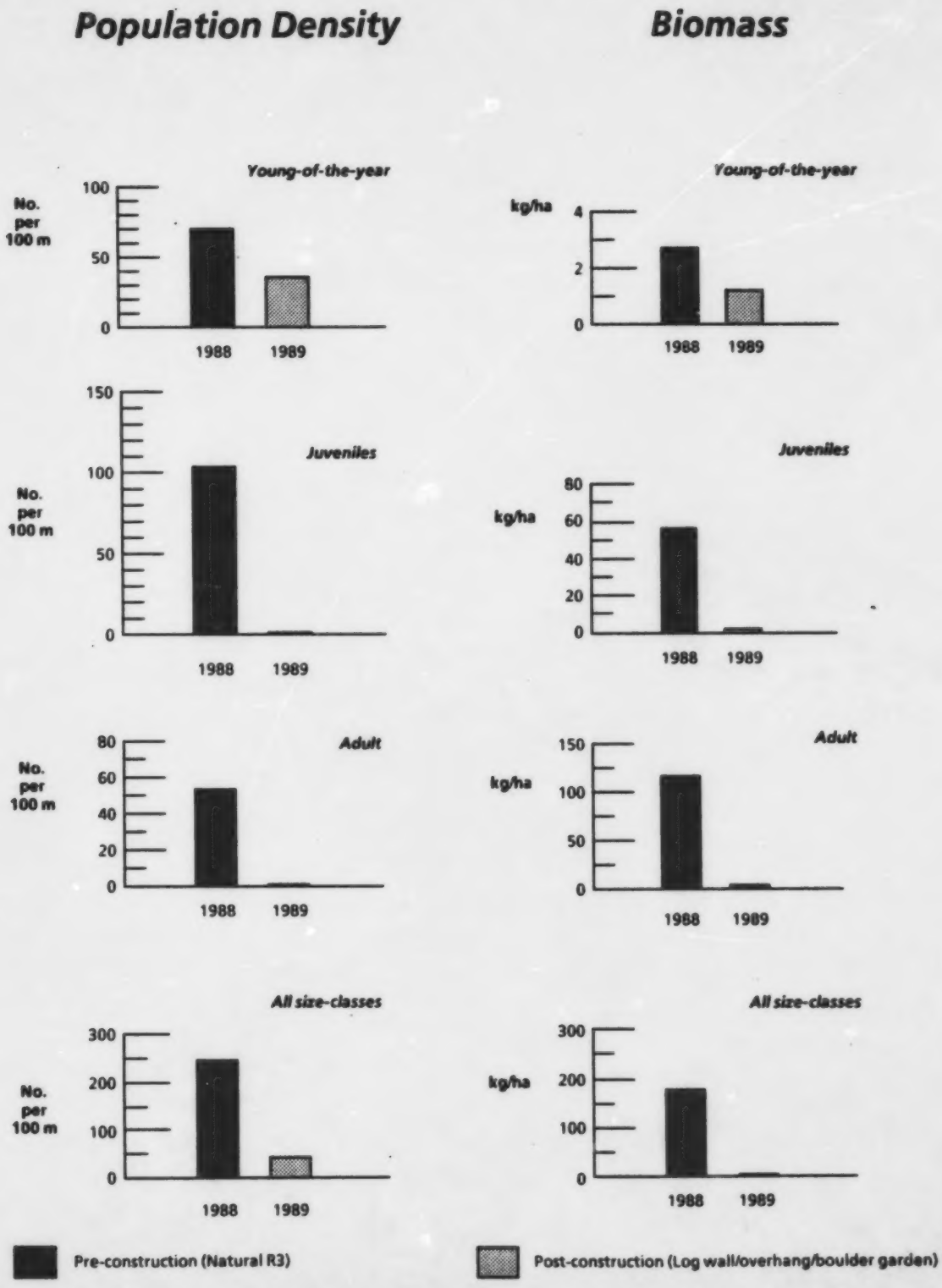

Figure 4.17 Estimates of mountain whitefish population density (standardized to number per 100 m) and biomass (kg/ha) at Site 88-11 on the Crowsnest River during 1988 and 1989, (pre and post-construction).

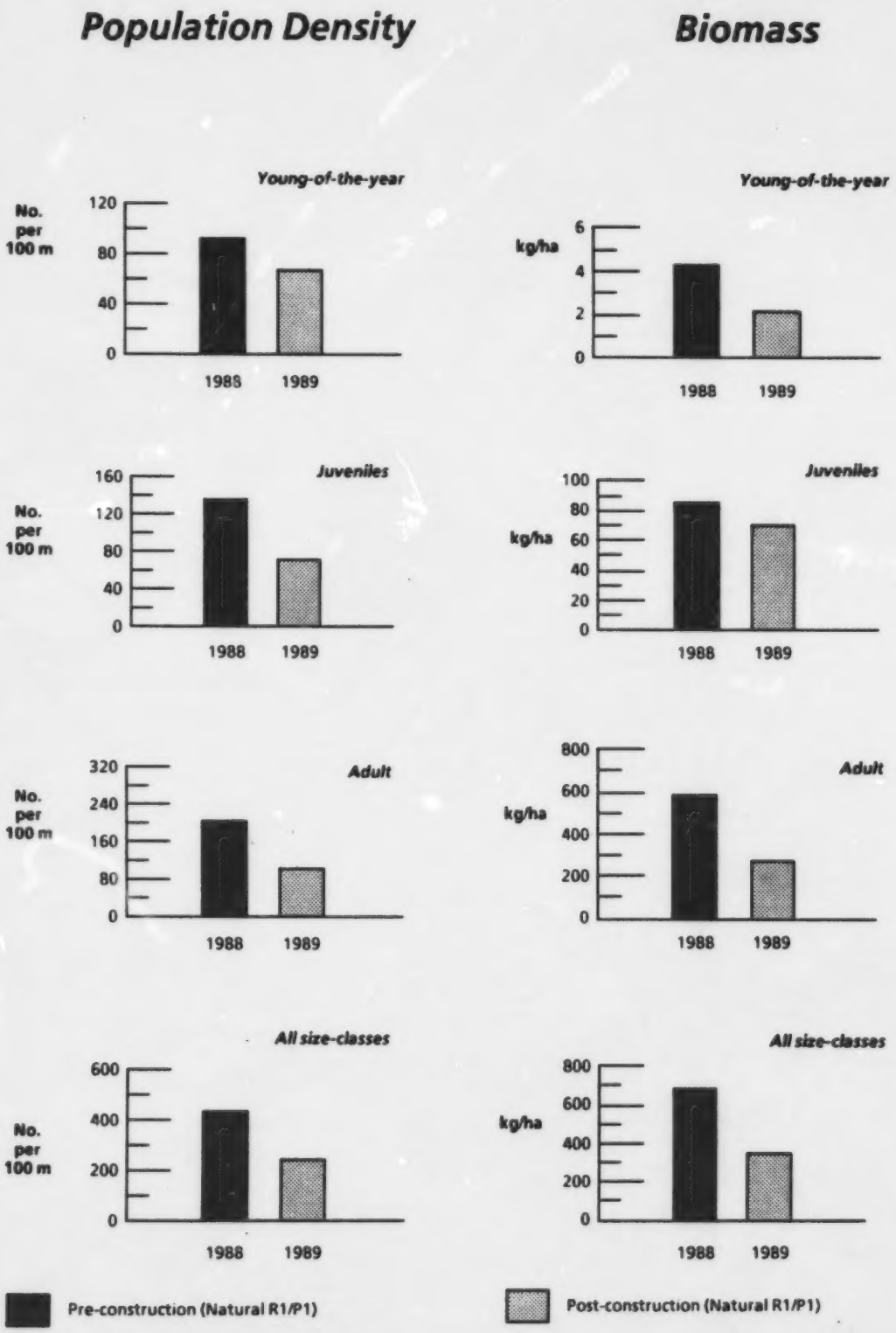

Figure 4.18 Estimates of mountain whitefish population density (standardized to number per 100 m) and biomass (kg/ha) at Site 87-K on the Crowsnest River during 1988 and 1989, (pre and post-construction).

SECTION 5.0
RESULTS OF 1989 SAMPLING PROGRAM - PRE-ENHANCEMENT

5.1 SAMPLE SITE DESCRIPTION

In total, 12 pre-enhancement (and associated control) sites were sampled in 1989. All sites were situated upstream of Lundbreck Falls. Most of the sites consisted of shallow run (R3) and riffle (RF) habitat types (Table 5.1). Exceptional in this regard was site 87-H, a high quality run/pool habitat (R1/P1) established as a temporal control in 1987. Site 87-G, a natural R3 (R2) habitat, was also designated a control site in 1987.

Table 5.1 Location and description of pre-enhanced and control sites, 1989.

Area	Site Description	Habitat Type/Description
Lundbreck	89-1	Natural R3/BG (RF/BG)
Burmis	89-2	Natural R3 (R2)
	89-3	Natural (R3 (R3/BG)
	89-4	Natural R2/P2 (R3)
	87-G (control)	Natural R3 (R2)
	87-H (control)	Natural R1/P1
Coleman	89-5	Natural R3/RF
	89-6	Natural R3/RF
	89-7	Natural R3/RF
	89-8	Natural R3/RF
	89-9	Natural R3/RF
	89-10	Natural R3/RF

5.2 NUMBERS AND PERCENTAGE COMPOSITION OF CATCH

In 1989, nine species of fish were encountered in the pre-enhancement sites. Included in the species assemblage were four sportfish (rainbow trout, rainbow/cutthroat hybrid, brook trout, and mountain whitefish). The two dominant species were rainbow trout and mountain whitefish; they contributed 2861 (61%) and 1253 (26%) individuals to the total catch, respectively. The major non-sportfish species was longnose dace (11% of total catch).

In terms of the size distribution of captured rainbow trout, the Lundbreck and Coleman sites were dominated by young-of-the-year and/or juveniles (Table 5.3). The deeper, better quality habitats in the vicinity of Burmis contained higher numbers of legal-sized (i.e., >254 mm) rainbow trout,

particularly in 87-H, the natural R1/P1 control. The distribution of non-sport and incidental species is provided in Table 5.4.

Table 5.2 Number and percentage composition of fish captured at pre-enhanced and control sites on the Crowsnest River, 1989.

Species		No. Captured	%
Common Name	Scientific Name		
Rainbow trout	*Oncorhynchus mykiss* (Richardson)[a]	2861	61
Cutthroat trout[b]	*Salmo clarki* Richardson	1	<1
Brook trout	*Salvelinus fontinalis* (Mitchill)	12	<1
Mountain whitefish	*Prosopium williamsoni* (Girard)	1253	26
White sucker	*Catostomus commersoni* (Lacépède)	5	<1
Mountain sucker	*Catostomus platyrhynchus* (Cope)	97	2
Longnose dace	*Rhinichthys cataractae* (Valenciennes)	511	11
Fathead minnow	*Pimephales promelas* Rafinesque	2	<1
Brook stickleback	*Culaea inconstans* (Kirtland)	1	<1
Total		4743	100%

[a]formerly *Salmo gairdneri*.
[b]Rainbow/cutthroat hybrid.

5.3 SIZE DISTRIBUTION OF CATCH

5.3.1 Rainbow Trout

The size distribution of rainbow trout captured at the population sites is presented graphically in Figure 5.1; the raw data is provided in Appendix D, Table D1. The length-frequency data illustrate that the shallow-water habitats were not utilized by adult or legal-sized cohorts for feeding/holding purposes (i.e., at that particular time of year and flow regime). In fact, very few trout larger than 254 cm were encountered in these areas (e.g., 89-1, 89-5, 89-7, 89-8). This does not reduce the importance of these habitats to young-of-the-year and juveniles for rearing or to adult fish during higher flows. Of interest is the presence of greater numbers of legal-sized trout in habitats with a moderate to high quality run (R2) component (e.g., 89-2, 89-4). Site 87-H (control) which constitutes a high quality adult feeding/holding area (i.e., R1/P1) had the highest numbers of larger fish and the most diverse size-class composition.

5.3.2 Mountain Whitefish

The size distribution of mountain whitefish captured at the various population sites is illustrated in Figure 5.2; the raw data is provided in Appendix E, Table E2. Only four of the 12 sites

Table 5.3 Summary of numbers and percentage composition of various size-classes of rainbow trout and mountain whitefish at pre-enhanced and control sites on the Crowsnest River, 1989.

Enhancement Area	Site	Rainbow Trout							Mountain Whitefish						
		Y-O-Y[a]		Juvenile[b]		Legal (≥254 mm)		Total	Y-O-Y[c]		Juvenile[d]		Adult (≥254 mm)		Total
		N	%	N	%	N	%	N	N	%	N	%	N	%	N
Near Lundbreck	89-1	80	99	1	1	0	-	81	-	-	-	-	-	-	0
Near Burmis	89-2	23	11	132	61	60	28	215	4	1	40	13	275	86	319
	89-3	224	84	34	13	8	3	266	18	46	0	-	21	54	39
	89-4	282	75	37	10	56	15	375	59	21	13	5	201	74	273
	87-G	147	60	66	27	32	13	245	5	2	56	27	149	71	210
	87-H	19	15	62	50	44	35	125	13	8	16	11	121	81	150
Near Coleman	89-5	109	20	429	79	3	1	541	3	2	155	96	3	2	161
	89-6	170	48	183	52	0	-	353	1	7	13	93	0	-	14
	89-7	96	66	50	34	0	-	146	0	-	3	100	0	-	3
	89-8	96	78	27	22	0	-	123	0	-	25	93	2	7	27
	89-9	157	86	25	14	0	-	182	1	100	0	-	0	-	1
	89-10	174	84	34	16	0	-	208	7	58	5	42	0	-	12

[a] At sites 89-1, 2, 3, 4; 87-G, H; length of y-o-y is <100 mm; at sites 89-5, 6, 7, 8, 9, 10; length of y-o-y is <70 mm.
[b] At sites 89-1, 2, 3, 4; 87-G, H; length of juveniles is 100-253 mm; at sites 89-5, 6, 7, 8, 9, 10; length of juveniles is 70-253 mm.
[c] At sites 89-1, 2, 3, 4; 87-G, K; length of y-o-y is <120 mm; at sites 89-5, 6, 7, 8, 9, 10; length of y-o-y is <100 mm.
[d] At sites 89-1, 2, 3, 4; 87-G, K; length of juveniles is 120-253 mm; at sites 89-5, 6, 7, 8, 9, 10; length of juveniles is 100-253 mm.

Table 5.4 Catch summary for incidental fish species captured at pre-enhanced and control sites on the Crowsnest River, 1989.

Enhancement Area	Site	Cutthroat trout[a]	Brook trout	White sucker	Mountain Sucker	Longnose Dace	Fathead minnow	Brook stickleback
Near Lundbreck	89-1					204		
Near Burmis	89-2					3		
	89-3	1				19		
	89-4					17		1
	87-G					5		
	87-H				1	1		
Near Coleman	89-5		10		42	117	2	
	89-6		2		3	83		
	89-7				4	42		
	89-8			5	47	19		
	89-9							
	89-10					1		

[a] Rainbow trout/cutthroat trout hybrid.

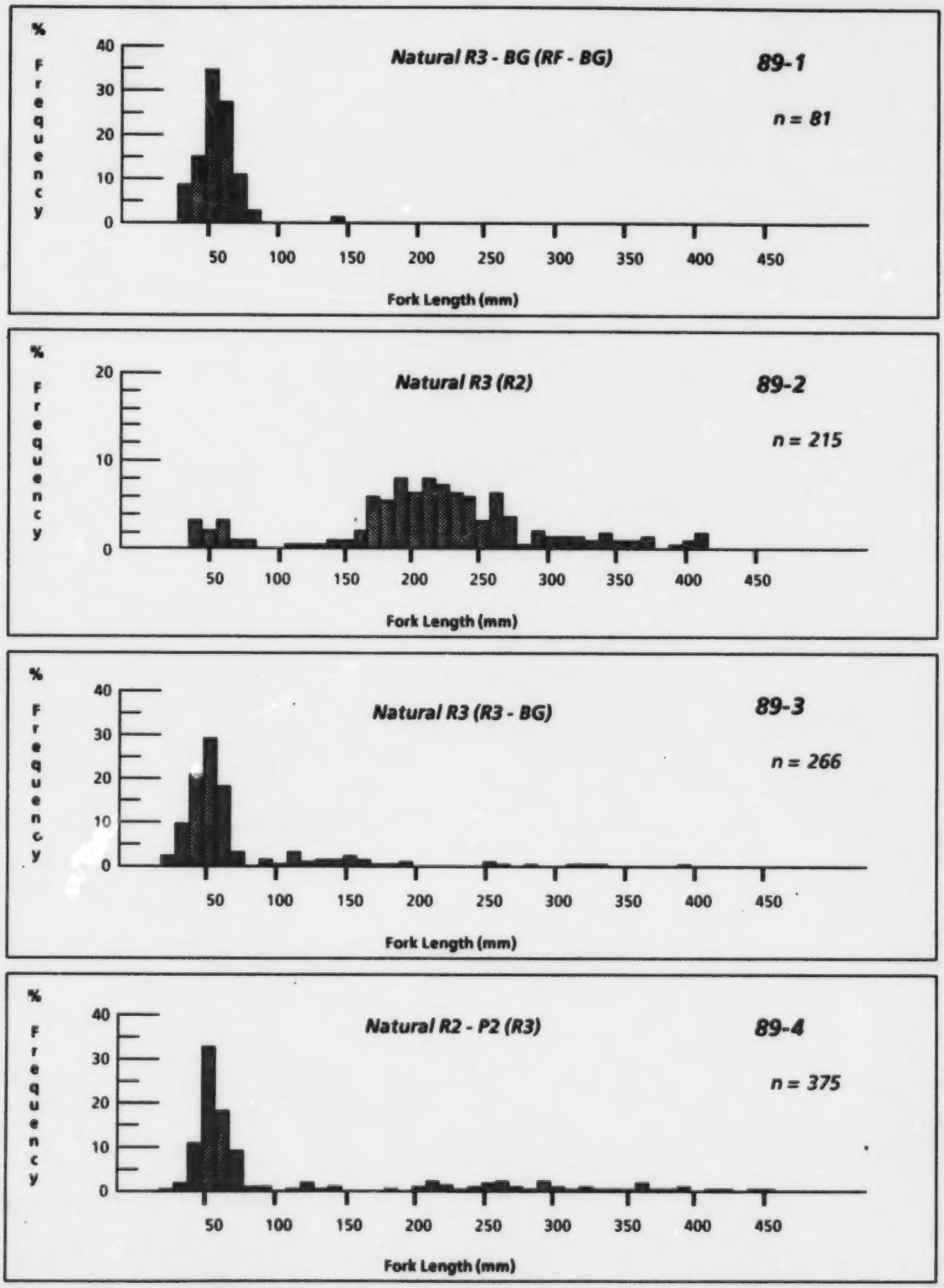

Figure 5.1 **Length-frequency distribution of rainbow trout from pre-enhanced and control sites on the Crowsnest River, 1989.**

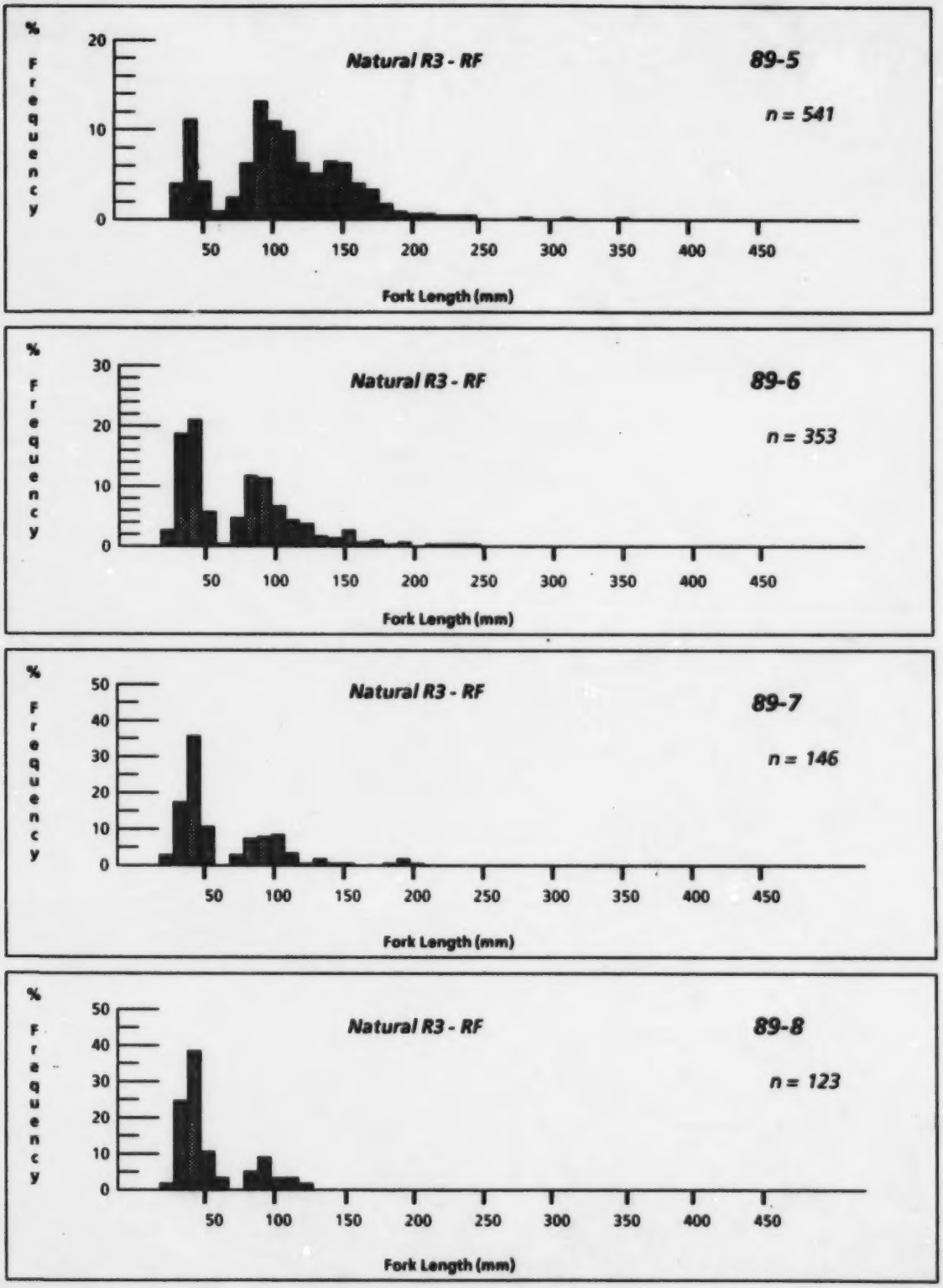

Figure 5.1 Continued.

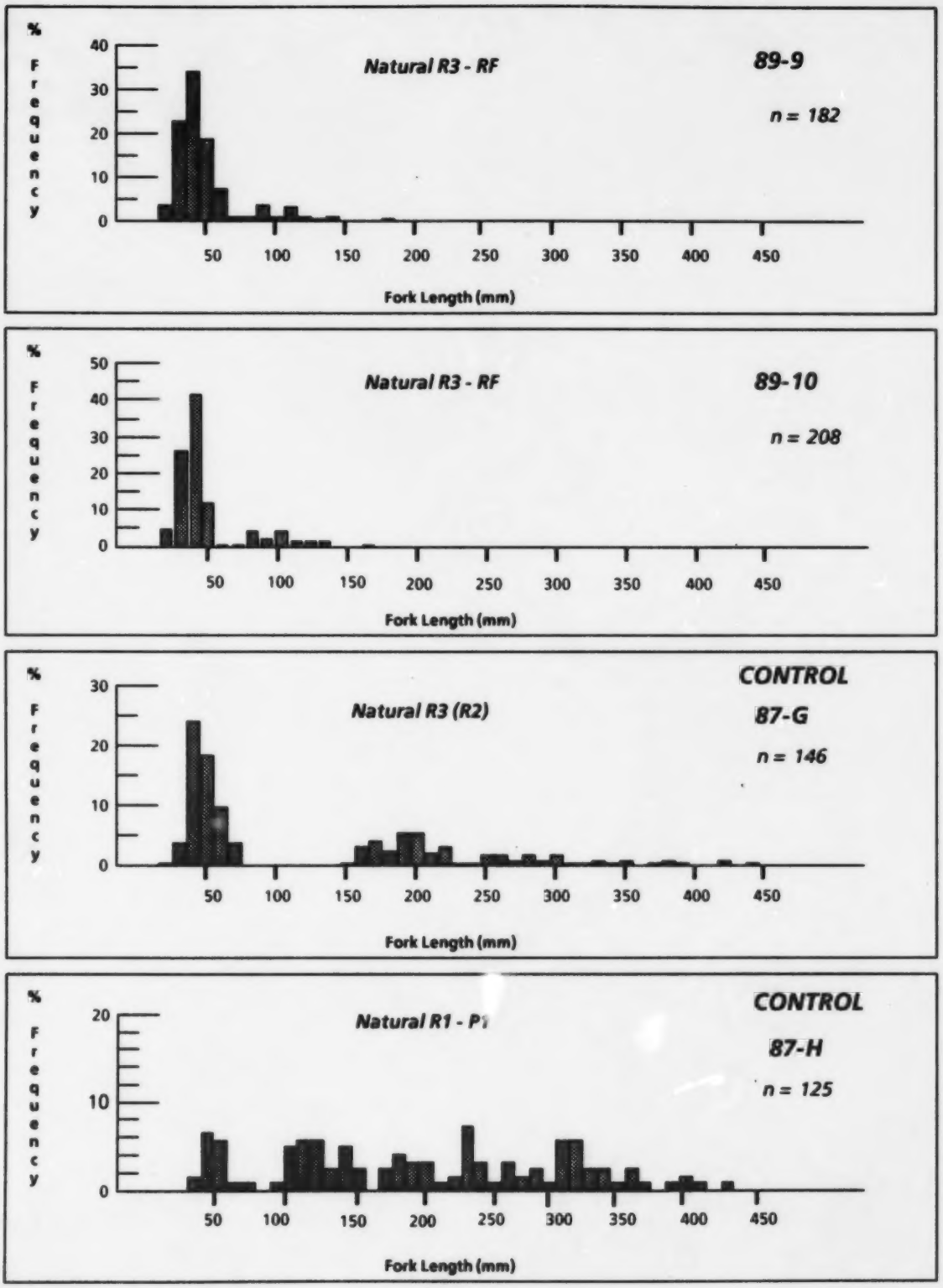

Figure 5.1 **Concluded.**

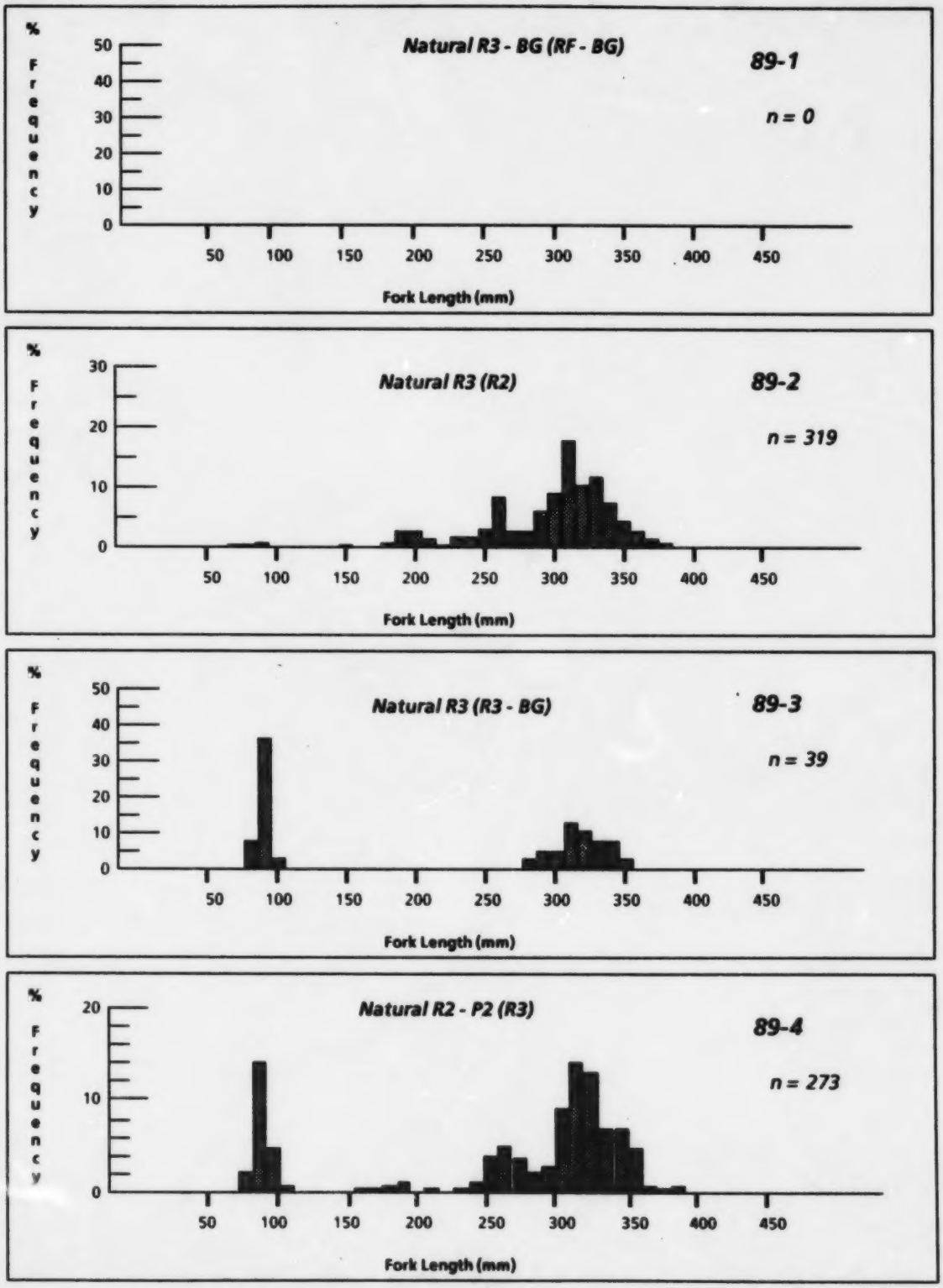

Figure 5.2 Length-frequency distribution of mountain whitefish from pre-enhanced and control sites on the Crowsnest River, 1989.

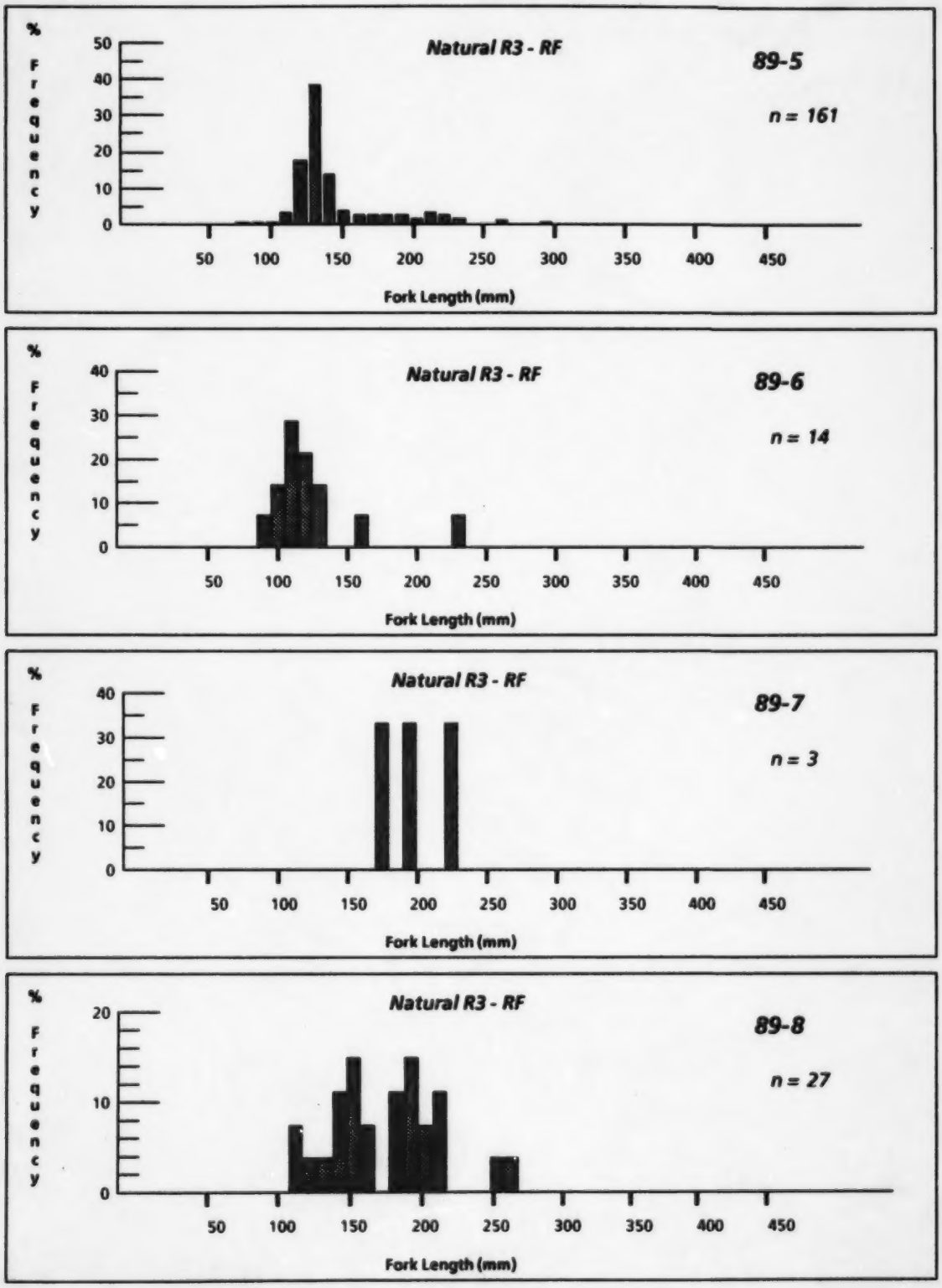

Figure 5.2 **Continued.**

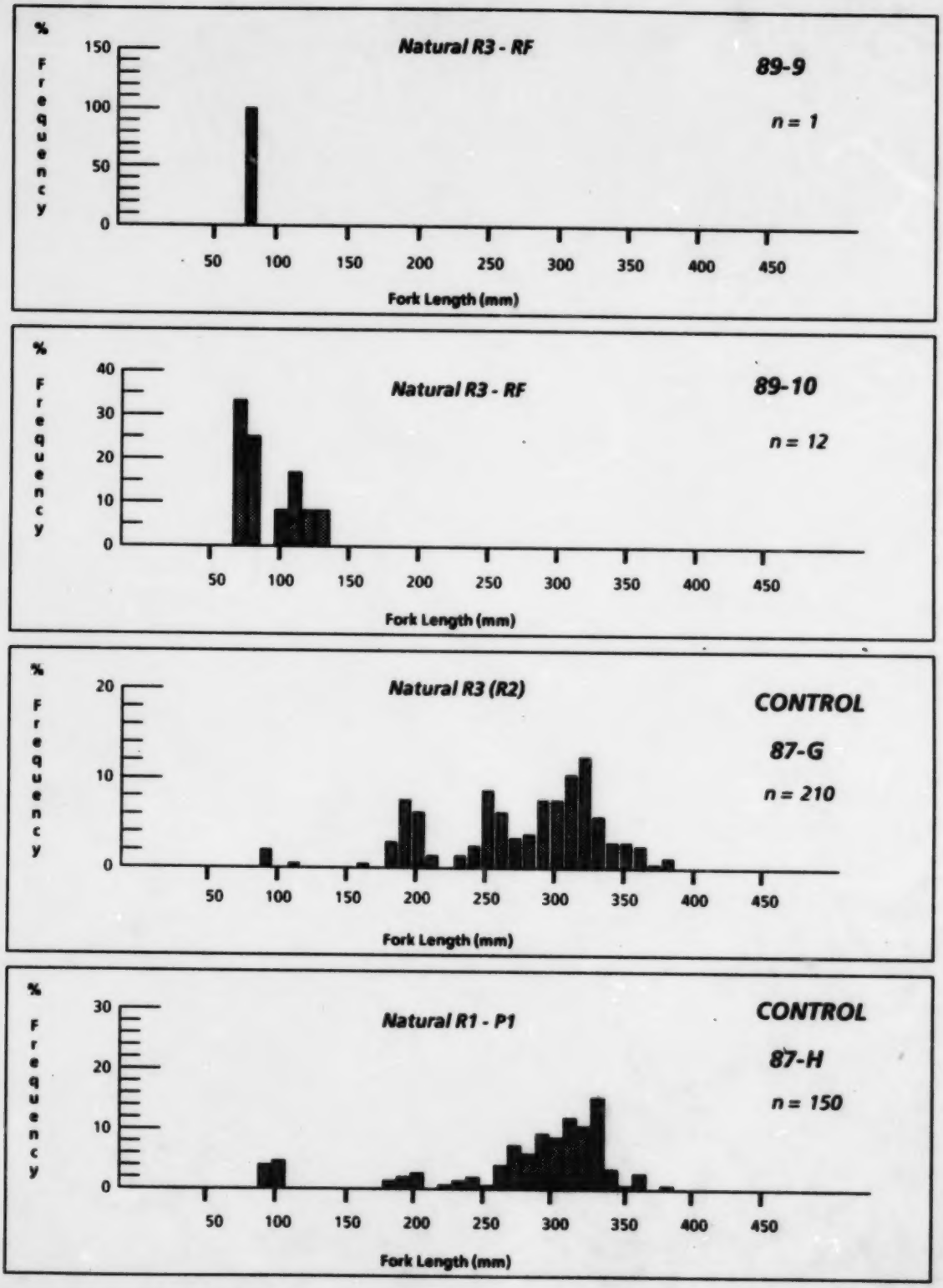

Figure 5.2 **Concluded.**

harbored high numbers of larger mountain whitefish; these were 89-2 (R3/R2), 89-4 (R2/P2), 87G (R3/R2), and 87-H (R1/P1). The remaining shallow habitat sites were occupied primarily by young-of-the-year and juveniles for rearing purposes. The size distribution at several of the sites was very sporadic; for example, sites 89-1, 89-3, 89-6, and 89-7.

5.4 POPULATION ESTIMATES (DENSITY AND BIOMASS)

5.4.1 Rainbow Trout

Population estimates using the multi-pass removal-depletion method were obtained for 12 sites; sampled length ranged at these sites from 32 to 70 m. Values for population density (standardized to number fish/100 m) were generated for young-of-the-year, juveniles, and legal-sized rainbow trout (Table 5.5). The individual density values and their comparative relationships are illustrated in Figure 5.3. The relative density of the various cohorts (y-o-y, juvenile, legal) appear to be directly related to the depth and cover characteristics of the site. For example, shallow habitats (dominated by RF and R3 cover types) were heavily utilized by y-o-y (and to a lesser extent juveniles) for rearing purposes. These habitats received only limited use by legal-size trout. The inverse appears to be true for high quality holding areas (e.g., 87-H).

Population densities of rainbow trout y-o-y ranged between 37 and 536 individuals per 100 m of stream section, with better rearing sites containing between 300-500 fish per 100 m. Juvenile densities ranged between 2-337 fish/100 m, with preferred habitats containing between 100-700 fish/100 m. Densities of legal-size trout ranged from 0-129 fish/100 m. Sites with densities of legal-sized trout greater than 100 fish/100 m can be considered preferred adult feeding/holding habitats. It is interesting to note that sites 89-2 and 89-4 held high numbers of larger trout despite their relatively shallow depth and lack of R1 or P1 habitat. This may have been partially due to the higher flows experienced in fall 1989 (at least in comparison to 1988).

Biomass values for the various sites are provided in Table 5.6 and Figure 5.4. These data show a similar trend to that observed for rainbow trout densities (i.e., higher values at sites with deeper water and better cover types). Biomass values for legal trout ranged between 0-278.0 kg/ha recorded. Sites with high quality habitats (i.e., 89-2, 89-4, 87-H) contained biomass values in the order of 200 kg/ha or higher.

Non-standardized population estimates (density for actual section sampled) and raw data for individual removal-depletion runs are provided in Appendix D, Tables D2 and D3.

Table 5.5 **Estimates of rainbow trout population density (standardized to number per 100 m) at pre-enhanced and control sites on the Crowsnest River, 1989.**

Enhancement Area	Site	Section Length (m)	SIZE-CLASS							
			Young-of-the-year[a]		Juveniles[b]		Legal (≥254 mm)		All Size-Classes	
			No. per 100 m	95% C.I.	No. per 100 m	95% C.I.	No. per 100 m	95% C.I.	No. per 100 m	95% C.I.
Near Lundbreck	89-1	65	134	123-149	>1[c]	n.c.[d]	0	-	135	125-150
Near Burmis	89-2	49	78	47-163	337	274-400	129	122-140	527	439-591
	89-3	50	536	473-599	68	68-72	>8	n.c.	594	526-640
	89-4	69	448	421-475	64	54-83	81	81-83	586	543-844
	87-G	55	385	273-498	127	120-140	58	58-59	520	445-571
	87-H	51	37	37-39	135	122-156	100	86-123	271	245-296
Near Coleman	89-5	64	192	170-216	711	686-736	5	5-6	908	845-940
	89-6	70	267	246-289	264	261-270	0	-	524	504-540
	89-7	43	232	223-247	121	116-131	0	-	356	340-374
	89-8	32	312	300-332	84	84-85	0	-	394	384-409
	89-9	40	400	392-412	65	62-75	0	-	465	455-479
	89-10	34	518	512-528	100	100-106	0	-	621	612-634

[a]At sites 89-1, 2, 3, 4; 87-G, H; length of y-o-y is <100 mm; at sites 89-5, 6, 7, 8, 9, 10; length of y-o-y is <70 mm.
[b]At sites 89-1, 2, 3, 4; 87-G, H; length of juveniles is 100-253 mm; at sites 89-5, 6, 7, 8, 9, 10; length of juveniles is 70-253 mm.
[c]Value given as actual catch; estimate would be greater than catch (population estimate not calculable due to ascending or irregular catch progression).
[d]Not calculated.

Table 5.6 **Estimates of rainbow trout standing stock biomass (kg/ha) at pre-enhanced and control sites on the Crowsnest River, 1989.**

Site	Sampled Area (ha)	SIZE-CLASS			
		Young-of-the-year[a] kg/ha ± 95% C.I.	Juveniles[b] kg/ha ± 95% C.I.	Legal (≥254 mm) kg/ha ± 95% C.I.	All Sizes kg/ha ± 95% C.I.
89-1	0.166	1.5 ± 0.3	0.3 ± n.a.[c]	0	1.8 ± 0.3
89-2	0.097	1.2 ± 1.4	209.2 ± 42.3	259.3 ± 38.5	469.8 ± 57.3
89-3	0.109	5.8 ± 0.9	12.5[d] ± n.c.[e]	26.1 ± 9.2	44.5 ± 9.6
89-4	0.122	7.5 ± 0.7	39.2 ± 14.4	198.8 ± 25.7	245.5 ± 29.4
87-G	0.088	4.9 ± 1.6	86.0 ± 11.9	154.4 ± 25.8	245.3 ± 28.5
87-H	0.078	0.7 ± 0.2	75.9 ± 18.5	278.0 ± 73.2	354.7 ± 75.5
89-5	0.065	2.4 ± 0.4	198.1 ± 19.0	16.9 ± 7.1	217.4 ± 20.3
89-6	0.089	2.1 ± 0.2	41.5 ± 8.1	0	43.5 ± 8.1
89-7	0.057	1.9 ± 0.2	17.7 ± 6.6	0	19.6 ± 6.6
89-8	0.045	2.7 ± 0.5	6.8 ± 1.3	0	9.4 ± 1.3
89-9	0.047	4.5 ± 0.5	10.2 ± 3.5	0	14.7 ± 3.5
89-10	0.040	4.6 ± 0.4	12.4 ± 2.9	0	16.9 ± 2.9

[a]At sites 89-1, 2, 3, 4; 87-G, H; length of y-o-y is <100 mm; at sites 89-5, 6, 7, 8, 9, 10; length of y-o-y is <70 mm.
[b]At sites 89-1, 2, 3, 4; 87-G, H; length of juveniles is 100-253 mm; at sites 89-5, 6, 7, 8, 9, 10; length of juveniles is 70-253 mm.
[c]Not applicable; confidence interval same as estimate.
[d]Actual catch value used to produce biomass estimate (population estimate not used for biomass estimate due to irregular or ascending catch progression).
[e]Not calculated.

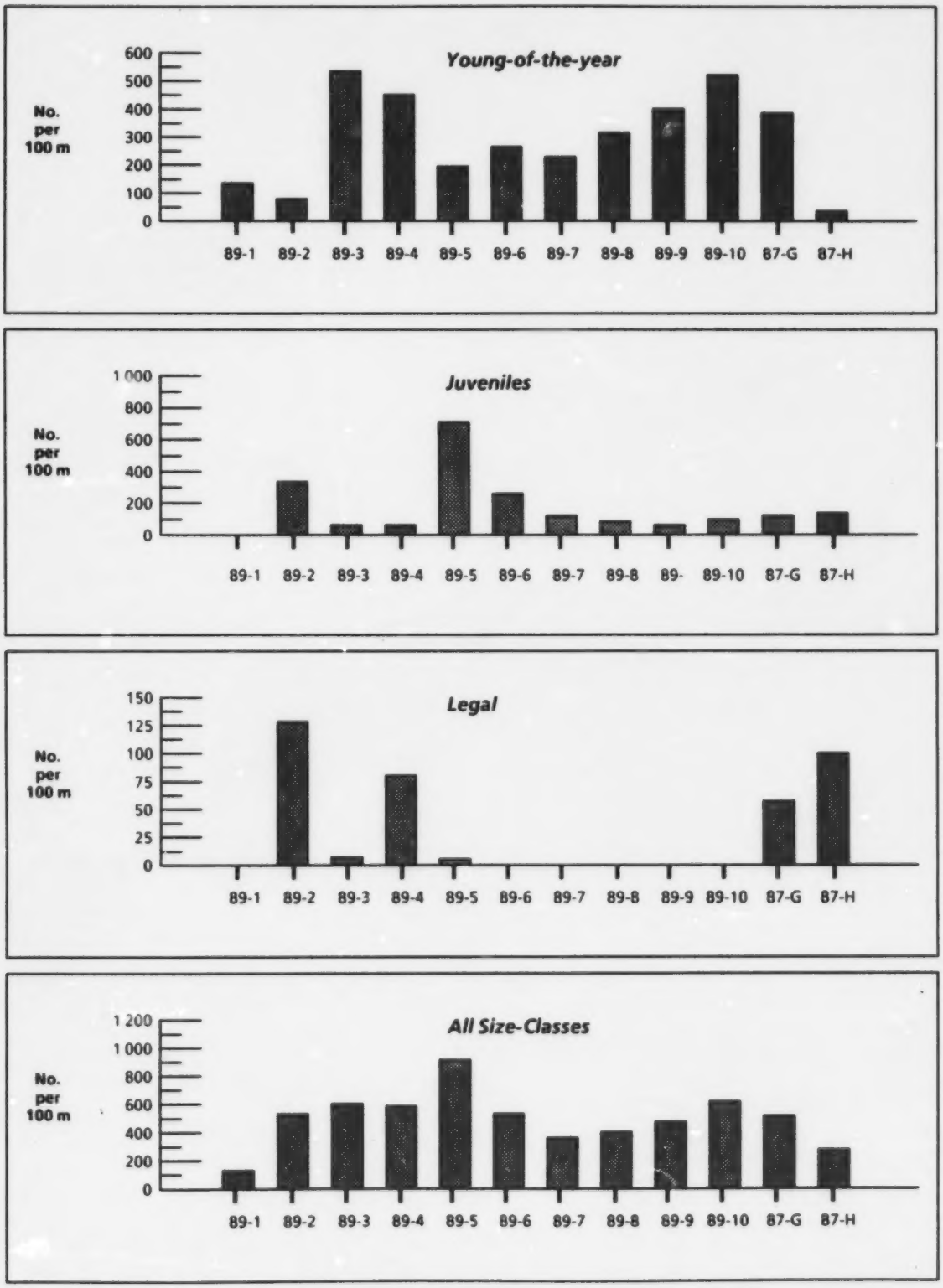

Figure 5.3 Estimates of rainbow trout population density (standardized to number per 100 m) at pre-enhanced and control sites on the Crowsnest River, 1989.

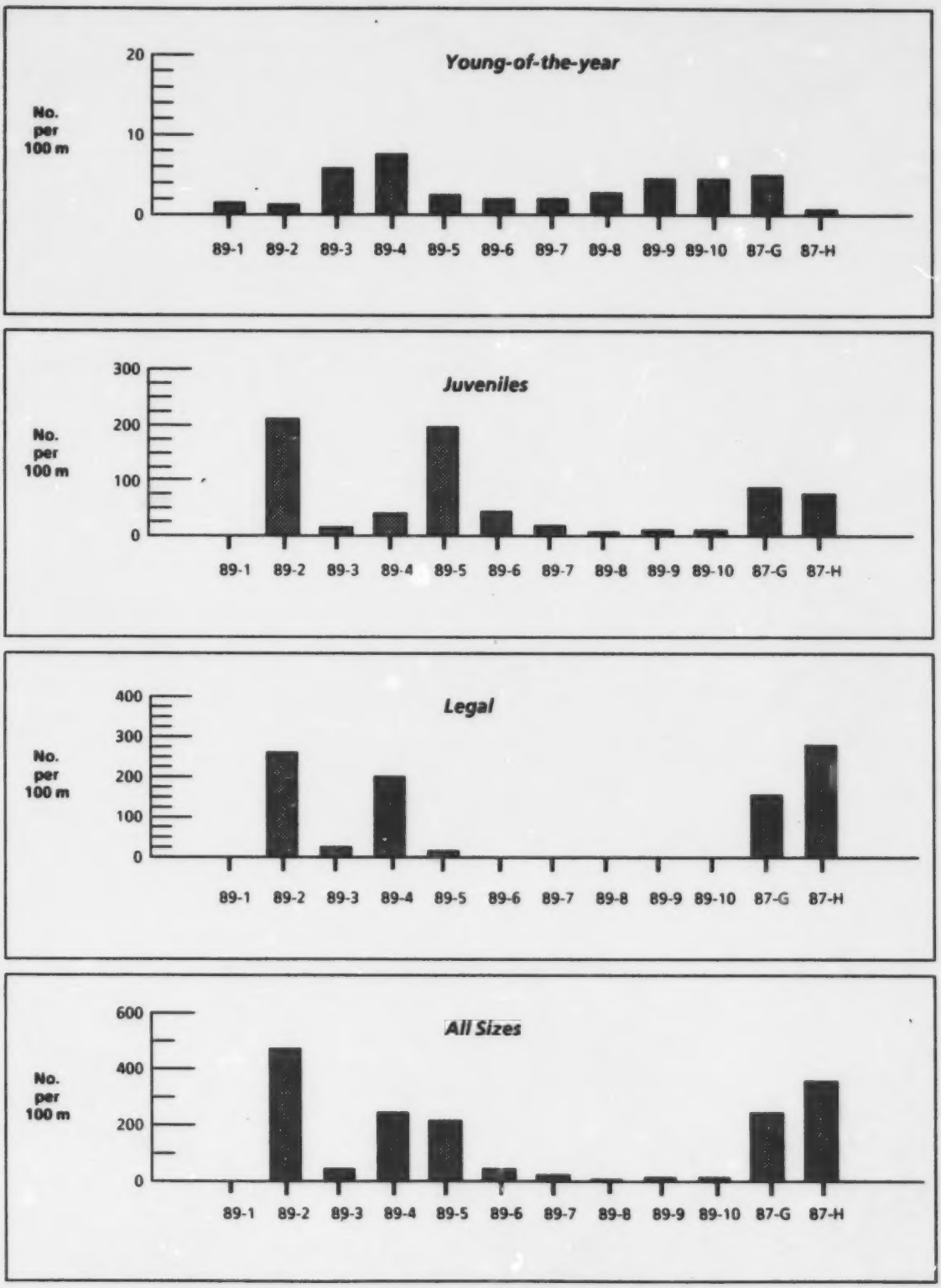

Figure 5.4 Estimates of rainbow trout standing stock biomass (kg/ha) at pre-enhanced and control sites on the Crowsnest River, 1989.

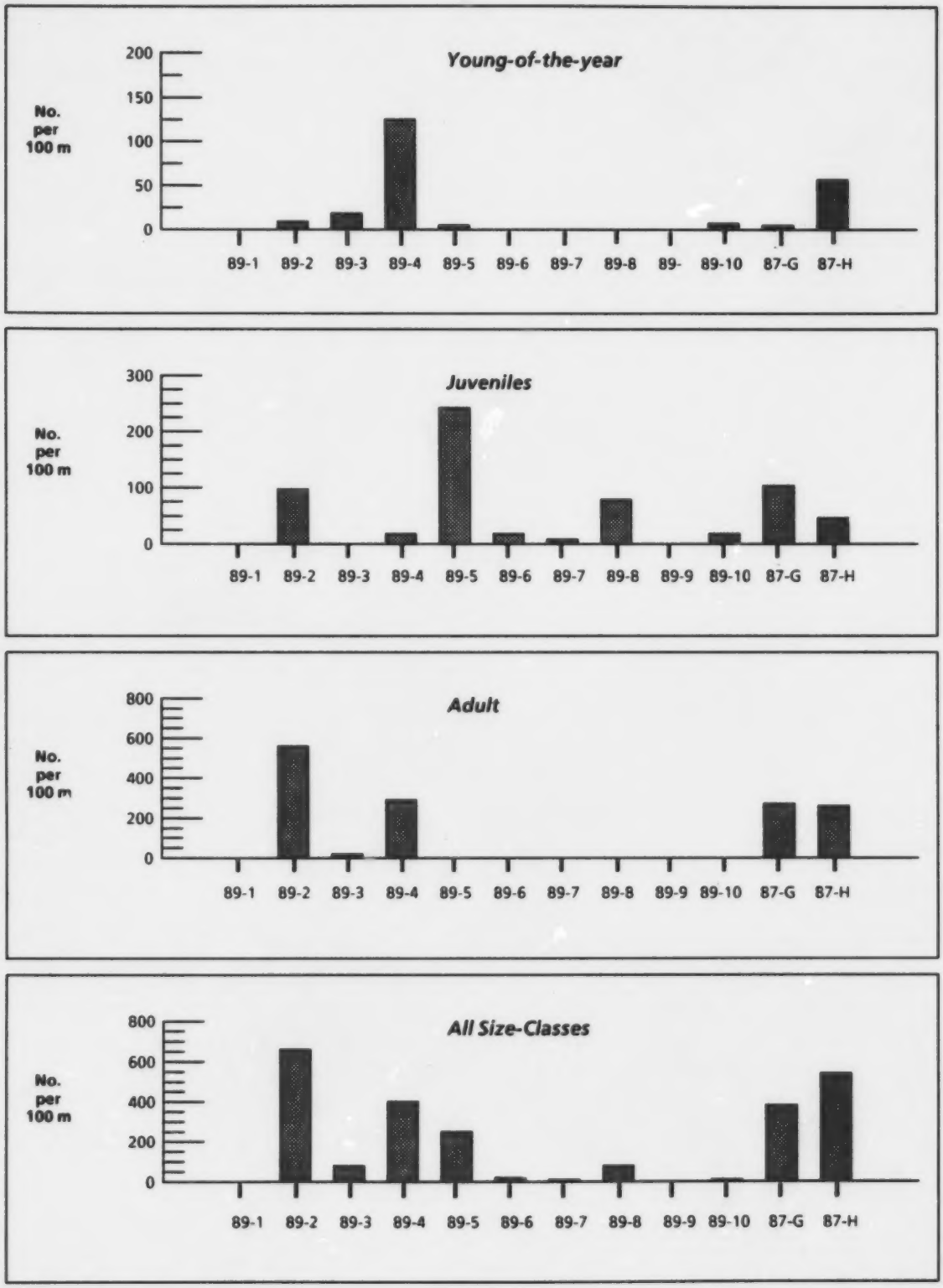

Figure 5.5 Estimates of mountain whitefish population density (standardized to number per 100 m) at pre-enhanced and control sites on the Crowsnest River, 1989.

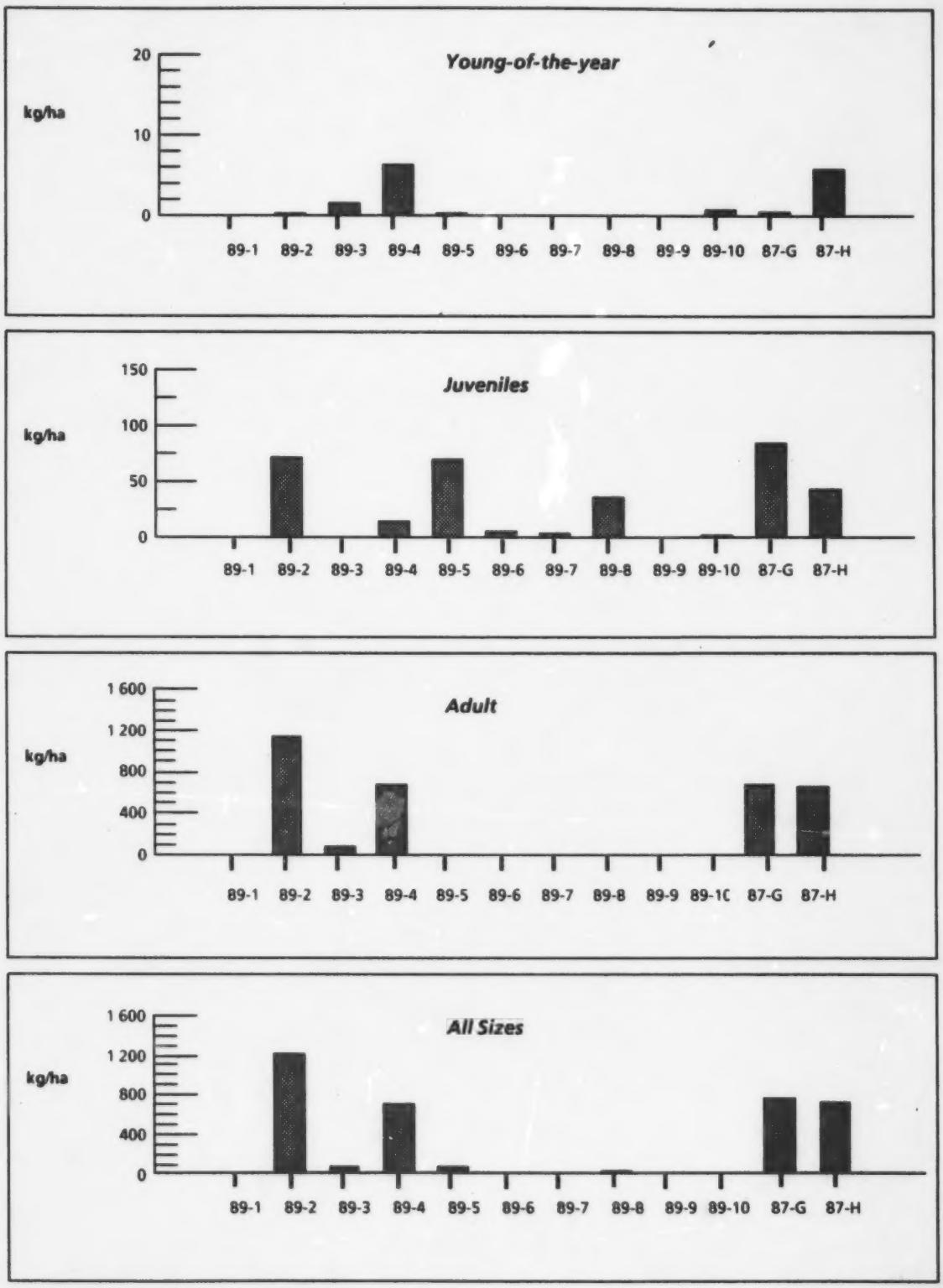

Figure 5.6 Estimates of mountain whitefish standing stock biomass (kg/ha) at pre-enhanced and control sites on the Crowsnest River, 1989.

Table 5.7 **Estimates of mountain whitefish population density (standardized to number per 100 m) at pre-enhanced and control sites on the Crowsnest River, 1989.**

Enhancement Area	Site	Section Length (m)	SIZE-CLASS							
			Young-of-the-year[a]		Juveniles[b]		Adult (≥254 mm)		All Size-Classes	
			No. per 100 m	95% C.I.	No. per 100 m	95% C.I.	No. per 100 m	95% C.I.	No. per 100 m	95% C.I.
Near Lundbreck	89-1	65	0	-	0	-	0	-	0	-
Near Burmis	89-2	49	8	8-9	98	82-128	563	561-569	659	651-669
	89-3	50	>18[c]	n.c.[d]	0	-	>21	n.c.	82	78-93
	89-4	69	126	86-189	19	19-21	291	291-293	401	396-409
	87-G	55	>5	n.c.	102	102-105	271	271-272	382	382-384
	87-H	51	>57[c]	n.c.	47	31-98	261	233-289	539	408-670
Near Coleman	89-5	64	5	5-6	242	242-244	>3	n.c.	252	252-254
	89-6	70	>1	n.c.	19	19-20	0	-	20	20-21
	89-7	43	0	-	7	7-10	0	-	7	7-10
	89-8	32	0	-	78	78-79	>2	n.c.	84	84-85
	89-9	40	>1	n.c.	0	-	0	-	>1	n.c.
	89-10	34	>7	n.c.	18	15-45	0	-	>12	n.c.

[a]At sites 89-1, 2, 3, 4; 87-G, K; length of y-o-y is <120 mm; at sites 89-5, 6, 7, 8, 9, 10; length of y-o-y is <100 m.
[b]At sites 89-1, 2, 3, 4; 87-G, K; length of juveniles is 120-253 mm; at sites 89-5, 6, 7, 8, 9, 10; length of juveniles is 100-253 mm.
[c]Value given as actual catch; population estimate would be greater than catch (population estimate not calculable due to ascending or irregular catch progression).
[d]Not calculated.

5.4.2 Mountain Whitefish

Population estimates (standardized density values and biomass values) are presented in Tables 5.7 and 5.8 and Figures 5.5 and 5.6. Non-standardized population estimates (density for actual section sampled) and raw data for individual removal-depletion runs is provided in Appendix E, Tables E2 and E3.

Table 5.8 Estimates of mountain whitefish standing stock biomass (kg/ha) at pre-enhanced and control sites on the Crowsnest River, 1989.

Site	Sampled Area (ha)	SIZE-CLASS			
		Young-of-the-year[a] kg/ha ± 95% C.I.	Juveniles[b] kg/ha ± 95% C.I.	Adult (≥254 mm) kg/ha ± 95% C.I.	All Sizes kg/ha ± 95% C.I.
89-1	0.166	0	0	0	0
89-2	0.097	0.3 ± 0.1	70.9 ± 23.5	1149.9 ± 34.7	1221.1 ± 41.9
89-3	0.109	1.4[d] ± n.c.[e]	0	83.1 ± n.c.	84.5 ± 5.9
89-4	0.122	6.3 ± 3.2	14.2 ± 3.8	676.1 ± 25.8	696.6 ± 26.2
87-G	0.088	0.6 ± 0.1	84.2 ± 9.1	680.5 ± 29.2	765.3 ± 30.6
87-H	0.078	5.8 ± n.c.	42.4 ± 44.5	666.9 ± 78.3	710.7 ± 90.1
89-5	0.065	0.3 ± 0.1	68.9 ± 10.0	9.5 ± n.c.	78.7 ± 10.1
89-6	0.089	0.1 ± n.a.[c]	4.5 ± 3.5	0	4.6 ± 3.5
89-7	0.057	0	3.9 ± 1.6	0	3.9 ± 1.6
89-8	0.045	0	35.3 ± 7.7	9.4 ± n.c.	44.8 ± 7.8
89-9	0.047	0.1 ± n.a.	0	0	0.1 ± n.a.
89-10	0.040	0.7 ± n.c.	1.9 ± 2.3	0	2.6 ± n.c.

[a]At sites 89-1, 2, 3, 4; 87-G, K; length of y-o-y is < 120 mm; at sites 89-5, 6, 7, 8, 9, 10; length of y-o-y is < 100 mm.
[b]At sites 89-1, 2, 3, 4; 87-G, K; length of juveniles is 120-253 mm; at sites 89-5, 6, 7, 8, 9, 10; length of juveniles is 100-253 mm.
[c]Not applicable; confidence interval same as estimate.
[d]Actual catch value used to produce biomass estimate (population estimate not used for biomass estimate due to irregular or ascending catch progression).
[e]Not calculated.

SECTION 6.0
LITERATURE CITED

Armour, C.L., K.P. Burham, and W.S. Platts. 1983. Field methods and statistical analyses for monitoring small salmonid streams. U.S. Fish and Wildl. Serv., FWS/OBS-83/33. 200 p.

R.L. & L. Environmental Services Ltd. 1989. Oldman River Project. Fish population enhancement evaluation, Crowsnest River, 1988. Data report prep. for Alberta Public Works, Supply and Services.

Van Deventer, J.S., and W.S. Platts. 1983. Sampling and estimating fish populations from streams. Trans. of the N. Am. Wildl. and Nat. Res. Conf. 48: 349-354.

_____. 1987. Users guide for MICROFISH 2.3, a software package for processing electrofishing data obtained by the removal method. For. Sci. Lab., Boise, Idaho. Unpubl. Mimeo. 6 p.

Zippin, C. 1958. The removal method of population estimation. J. Wildl. Manage. 22(1): 89-90.

APPENDIX A

HABITAT CLASSIFICATION AND RATING SYSTEM (R.L. & L.)

APPENDIX A
HABITAT CLASSIFICATION AND RATING SYSTEM

A) Riffle - Portion of channel with increased velocity relative to Run and Pool habitat types; broken water surface due to effects of submerged or exposed bed materials; relatively shallow (less than 25 cm) during moderate to low flow periods.

Riffle (RF) - Typical riffle habitat type; limited submerged or overhead cover for juveniles and adult life stages; coarse substrate

Riffle-Boulder garden (RF/BG) - Riffle habitat type with significant occurrence of large boulders; availability of significant instream cover for juveniles (to lesser extent adults) at moderate to high flow events.

B) Rapids (RA) - Portion of channel with highest velocity relative to other habitat types. Deeper than Riffle (ranging from 25-50 cm); often formed by channel constriction. Substrate extremely coarse; dominated by large cobble and boulder material. Instream cover provided in pocket eddies (P3) and associated with cobble/boulder substrate.

C) Run - Portion of channel characterized by moderate to high current velocity relative to Pool and Flat habitat; water surface largely unbroken. Deeper than Riffle habitat type. Can be differentiated into four types; deep-slow, deep-fast, shallow-slow, and shallow-fast.

Run (Class 1) (R1) - Highest quality Run habitat type. Maximum depth exceeding 1.5 m; average depth 1.0 m. High instream cover at all flow conditions (submerged boulders/bedrock fractures, depth). Generally of deep-slow type (to lesser extent deep-fast) and situated proximal to upstream food production area (i.e., RF, R3).

Run (Class 2) (R2) - Moderate quality Run habitat type. Maximum depth reaching or exceeding 1.0 m, generally exceeding 0.75 m. High instream cover during all but low flow events (baseflow). Generally of either deep-fast type or moderately deep-slow type.

Run (Class 2)/Boulder garden (R2/BG) - Moderate quality Run habitat type; presence of large boulders in channel; high instream cover (boulder, bedrock fractures, turbulence) at all but low-flow events (baseflow). Depth characteristics similar to R2; however, required maximum depth lower due to cover afforded by boulders.

Run (Class 3) (R3) - Lowest quality Run habitat type. Maximum depth of 0.75 m, but averaging <0.50 m. Low instream cover at all but high flow events. Generally of shallow-fast or shallow-slow types.

Run (Class 3)/Boulder garden (R3/BG) - Similar to R3 in depth and velocity characteristics; presence of large boulders in channel offers improved instream cover during moderate and high flow events.

D) Flat (FL) - Area of channel characterized by low current velocities (relative to RF and Run cover types); near-laminar (i.e., non-turbulent) flow character. Depositional area featuring predominantly sand/silt substrate. Differentiated from Pool habitat type on basis of high channel uniformity and lack of direct riffle/run association. More depositional in nature than R3 habitat (sand/silt substrate, lower food production, low cover, etc.).

Flat (Class 1) (F1) High quality Flat habitat type. Maximum depth exceeding 1.5 m; average depth 1.0 m or greater.

Flat (Class 2) (F2) Moderate quality Flat habitat type. Maximum depth exceeding 1.0 m; generally exceeding 0.75 m.

Flat (Class 3) (F3) Low quality Flat habitat type. Maximum depth of 0.75 m, averaging less than <0.50 m.

E) Pool - Discrete portion of channel featuring increased depth and reduced velocity (downstream oriented) relative to Riffle and Run habitat types.

Pool (Class 1) (P1) - Highest quality Pool habitat type. Maximum depth exceeding 1.5 m; average depth 1.0 m or greater; high instream cover at all flow-conditions (submerged boulder, bedrock fractures, depth, bank irregularities). Generally featuring high Riffle and/or Run association (i.e., food input). Often intergrades with deep-slow type of R1.

Pool (Class 2) (P2) - Moderate quality Pool habitat type. Maximum depth reaching or exceeding 1.0 m, generally exceeding 0.75 m. High instream cover at all but low flow events (baseflow).

Pool Class 3) (P3) - Low quality pool habitat type. Maximum depth of 0.75 m, averaging <0.50 m. Low instream cover at all but high flow events. Includes small pocket eddy type of habitat.

F) Features - Includes the following instream features:

Chutes (CH) - Area of channel constriction; generally resulting in channel deepening and increased velocity. Associated habitat types are R1, R1, R2.

Ledges (LG) - Areas of bedrock intrusion into the channel; often creates Chutes and Pool habitat.

Other - Miscellaneous features (fallen tree, large boulder, etc.)

APPENDIX B

LENGTH-FREQUENCY DISTRIBUTION AND POPULATION ESTIMATE DATA FOR RAINBOW TROUT (POST-ENHANCEMENT AND ASSOCIATED CONTROL SITES)

Appendix B, Table B1 Length-frequency distribution of rainbow trout at enhanced and control sites on the Crowsnest River during 1989 (post-construction).

Length Interval (mm)	88-1		88-2		88-3		88-7		88-9		88-10	
	#	%	#	%	#	%	#	%	#	%	#	%
10-19												
20-29					7	2.3						
30-39	1	0.4			14	4.6	7	9.3	3	1.9	5	1.8
40-49	10	3.5	17	2.0	33	10.8	28	37.3	28	18.2	26	9.5
50-59	11	3.9	41	4.8	26	8.5	12	16.0	13	8.4	24	8.8
60-69	3	1.1	8	0.9	11	3.6			1	0.6	2	0.7
70-79												
80-89	1	0.4							1	0.6	8	2.9
90-99	3	1.1	3	0.3	1	0.3	1	1.3	9	5.8	22	8.0
100-109	6	2.1	11	1.3	1	0.3	1	1.3	22	14.3	43	15.7
110-119	15	5.3	25	2.9	2	0.7	11	14.7	13	8.4	47	17.2
120-129	24	8.4	57	6.6	2	0.7	1	1.3	20	13.0	23	8.4
130-139	24	8.4	63	7.3	1	0.3	4	5.3	3	1.9	18	6.6
140-149	39	13.7	100	11.6	3	1.0	2	2.7	5	3.2	13	4.7
150-159	21	7.4	108	12.6	4	1.3	1	1.3	5	3.2	11	4.0
160-169	24	8.4	86	10.0	8	2.6			5	3.2	8	2.9
170-179	25	8.8	79	9.2	16	5.2	1	1.3	3	1.9	7	2.6
180-189	23	8.1	65	7.6	17	5.6			2	1.3	4	1.5
190-199	16	5.6	49	5.7	26	8.5			3	1.9	2	0.7
200-209	17	6.0	34	4.0	34	11.1	1	1.3	2	1.3	4	1.5
210-219	5	1.8	28	3.3	30	9.8			2	1.3		
220-229	8	2.8	23	2.7	19	6.2			6	3.9		
230-239	3	1.1	24	2.8	15	4.9			1	0.6		
240-249	2	0.7	13	1.5	10	3.3	1	1.3			1	0.4
250-259			4	0.5	5	1.6					1	0.4
260-269	1	0.4	3	0.3	4	1.3	2	2.7	2	1.3		
270-279	1	0.4	4	0.5	4	1.3	1	1.3			1	0.4
280-289	2	0.7	4	0.5	3	1.0			2	1.3		
290-299					4	1.3						
300-309									1	0.6		
310-319			2	0.2	3	1.0			1	0.6	1	0.4
320-329			1	0.1	1	0.3					2	0.7
330-339			2	0.2								
340-349			2	0.2								
350-359			3	0.3								
360-369												
370-379							1	1.3	1	0.6		
380-389					1	0.3						
390-399												
400-409												
410-419												
420-429											1	0.4
430-439												
440-449												
450-459												

Continued...

Appendix B, Table B1 Continued.

Length Interval (mm)	88-11		87-K	
	#	%	#	%
10-19	1	0.6		
20-29	1	0.6		
30-39	9	5.7	5	1.4
40-49	42	26.6	18	5.0
50-59	16	10.1	16	4.4
60-69	2	1.3	5	1.4
70-79	1	0.6	1	0.3
80-89	1	0.6	15	4.2
90-99	13	8.2	23	6.4
100-109	20	12.7	61	16.9
110-119	19	12.0	59	16.4
120-129	9	5.7	38	10.6
130-139	7	4.4	23	6.4
140-149	4	2.5	21	5.8
150-159	3	1.9	15	4.2
160-169	4	2.5	19	5.3
170-179	4	2.5	6	1.7
180-189	1	0.6	5	1.4
190-199			7	1.9
200-209	1	0.6	2	0.6
210-219			3	0.8
220-229			4	1.1
230-239			1	0.3
240-249			1	0.3
250-259				
260-269			2	0.6
270-279			2	0.6
280-289			3	0.8
290-299				
300-309			1	0.3
310-319			1	0.3
320-329			1	0.3
330-339			1	0.3
340-349				
350-359			1	0.3
360-369				
370-379				
380-389				
390-399				
400-409				
410-419				
420-429				
430-439				
440-449				
450-459				

Appendix B, Table B2 **Non-standardized estimates of rainbow trout population density (actual estimates for sampled sections) at enhanced and control sites on the Crowsnest River during 1989 (post-construction).**

Enhancement Area	Site	Sample Date	Section Length (m)	SIZE-CLASS							
				Young-of-the-year (<80 mm)		Juveniles (80-253 mm)		Legal (≥ 254 mm)		All Size-Classes	
				No. per 100 m	95% C.I.	No. per 100 m	95% C.I.	No. per 100 m	95% C.I.	No. per 100 m	95% C.I.
Near Bellevue	88-1	16 Sep.	71	31	25-45	283	267-299	4	n.a.[a]	317	299-335
	88-2	17 Sep.	63	67	66-70	2851	879-4823	24	24-26	2034	1354-2714
	88-3*	19 Sep.	52	101	91-113	198	190-206	24	24-25	322	309-335
Near Frank	88-7	26 Sep.	57	58	47-76	26	24-32	4	4-7	90	75-109
	88-9	27 Sep.	49	53	45-67	118	102-136	0	-	177	157-197
	88-10	28 Sep.	103	82	57-121	216	211-222	6	6-7	288	277-299
	88-11	29 Sep.	143	82	72-95	96	86-108	0	-	179	160-198
	87-K*	30 Sep.	65.5	47	45-52	327	311-343	12	12-13	387	370-404

[a]Not applicable; confidence interval (C.I.) same as population estimate.
*Control site.

Appendix B, Table B3 Removal-depletion data for rainbow trout population at enhanced and control sites on the Crowsnest River during 1989 (post-construction).

Site	Section Length (m)	SIZE CLASS																					
		Young-of-the-Year (<80 mm)						Juveniles (80-253 mm)						Legal (≥254 mm)						All Size Classes					
		No. Capt./Run					Pop. Est. (95% C.I.)	No. Capt./Run					Pop. Est. (95% C.I.)	No. Capt./Run					Pop. Est. (95% C.I.)	No. Capt./Run					Pop. Est. (95% C.I.)
		R1	R2	R3	R4	T		R1	R2	R3	R4	T		R1	R2	R3	R4	T		R1	R2	R3	R4	T	
88-1	71	10	7	3	5	25	31(25-45)	130	74	38	19	261	283(267-299)	4	-	-	-	4	4(n.a.)[a]	144	81	41	24	290	317(299-335)
88-2	63	36	26	4	0	66	67(66-70)	163	241	234	131	769	2851(879-4823)	16	3	5	0	24	24(24-26)	215	270	243	131	859	2034(1354-2714)
88-3*	52	55	22	14	-	91	101(91-113)	125	52	13	-	190	198(190-206)	18	6	0	-	24	24(24-25)	198	80	27	-	305	322(309-335)
88-7	57	26	10	11	-	47	58(47-76)	14	6	4	-	24	26(24-32)	2	1	1	-	4	4(4-7)	42	17	16	-	75	90(75-109)
88-9	49	25	11	9	-	45	53(45-67)	54	34	14	-	102	118(102-136)	0	0	0	-	0	-	86	45	23	-	154	177(157-197)
88-10	103	29	12	16	-	57	82(57-121)	146	57	8	-	211	216(211-222)	5	0	1	-	6	6(6-7)	180	69	25	-	274	288(277-299)
88-11	143	36	29	7	-	72	82(72-95)	55	14	17	-	86	96(86-108)	0	0	0	0	0	-	91	43	24	-	158	179(160-198)
87-K*	65.5	26	16	3	-	45	47(45-52)	191	76	36	-	303	327(311-343)	9	2	1	-	12	12(12-13)	226	94	40	-	360	387(370-404)

[a]Not applicable; confidence interval (C.I.) same as population estimate.
*Control site.

APPENDIX C

LENGTH-FREQUENCY DISTRIBUTION AND POPULATION ESTIMATE DATA FOR MOUNTAIN WHITEFISH (POST-ENHANCEMENT AND ASSOCIATED CONTROL SITES)

Appendix C, Table C1 Length-frequency distribution of mountain whitefish at enhanced and control sites on the Crowsnest River during 1989 (post-construction).

Length Interval (mm)	88-1		88-2		88-3		88-7		88-9		88-10	
	#	%	#	%	#	%	#	%	#	%	#	%
10-19												
20-29												
30-39												
40-49												
50-59												
60-69					2	1.8			12	22.6	31	42.5
70-79					7	6.4	2	5.1	16	30.2	34	46.6
80-89	5	13.9	3	0.9	8	7.3	2	5.1	3	5.7	5	6.8
90-99	21	58.3	24	6.9	7	6.4						
100-109	3	8.3	4	1.1	3	2.8						
110-119			1	0.3							1	1.4
120-129												
130-139			1	0.3								
140-149												
150-159			2	0.6								
160-169			17	4.9								
170-179			31	8.9	1	0.9						
180-189			35	10.0	3	2.8						
190-199			25	7.2					3	5.7		
200-209	1	2.8	7	2.0			1	2.6	2	3.8		
210-219			4	1.1	2	1.8	2	5.1	2	3.8		
220-229			12	3.4	9	8.3	4	10.3	2	3.8		
230-239			21	6.0	10	9.2	2	5.1				
240-249			19	5.4	11	10.1	1	2.6	2	3.8		
250-259			22	6.3	12	11.0	2	5.1	3	5.7		
260-269			21	6.0	7	6.4	3	7.7	3	5.7		
270-279	1	2.8	16	4.6	5	4.6	4	10.3	1	1.9		
280-289	1	2.8	20	5.7	2	1.8	3	7.7	1	1.9	1	1.4
290-299			13	3.7	2	1.8	2	5.1				
300-309	2	5.6	22	6.3	3	2.8	1	2.6	1	1.9		
310-319	1	2.8	9	2.6	5	4.6	6	15.4	1	1.9		
320-329			12	3.4	4	3.7	2	5.1				
330-339	1	2.8	3	0.9	1	0.9	2	5.1	1	1.9		
340-349			3	0.9	4	3.7						
350-359			1	0.3								
360-369					1	0.9					1	1.4
370-379			1	0.3								
380-389												
390-399												
400-409												
410-419												
420-429												
430-439												
440-449												
450-459												

Continued...

Appendix C, Table C1 Continued.

Length Interval (mm)	88-11		87-K	
	#	%	#	%
10-19				
20-29				
30-39				
40-49				
50-59				
60-69	12	30.8	7	4.5
70-79	20	51.3	25	16.1
80-89	2	5.1	8	5.2
90-99				
100-109	1	2.6		
110-119				
120-129			1	0.6
130-139				
140-149				
150-159				
160-169			1	0.6
170-179				
180-189			3	1.9
190-199			1	0.6
200-209			7	4.5
210-219			12	7.7
220-229			6	3.9
230-239			7	4.5
240-249	2	5.1	4	2.6
250-259			6	3.9
260-269			3	1.9
270-279			6	3.9
280-289			6	3.9
290-299			11	7.1
300-309	1	2.6	11	7.1
310-319	1	2.6	10	6.5
320-329			12	7.7
330-339			4	2.6
340-349			3	1.9
350-359			1	0.6
360-369				
370-379				
380-389				
390-399				
400-409				
410-419				
420-429				
430-439				
440-449				
450-459				

Appendix C, Table C2 **Non-standardized estimates of mountain whitefish population density (actual estimates for sampled sections) at enhanced and control sites on the Crowsnest River during 1989 (post-construction).**

Enhancement Area	Site	Sample Date	Section Length (m)	SIZE-CLASS							
				Young-of-the-year (<120 mm)		Juveniles (120-253 mm)		Adult (≥254 mm)		All Size-Classes	
				No. per 100 m	95% C.I.	No. per 100 m	95% C.I.	No. per 100 m	95% C.I.	No. per 100 m	95% C.I.
Near Bellevue	88-1	16 Sep.	71	145	29-962	1	n.a.[a]	6	6-8	180	36-1071
	88-2	17 Sep.	63	1031	1014-1048	900	180-2806	168	140-196	1426	1389-1462
	88-3*	19 Sep.	52	425	85-1797	44	44-46	38	38-39	230	176-284
Near Frank	88-7	26 Sep.	57	4	4-6	50	10-538	125	25-863	195	39-1113
	88-9	27 Sep.	49	155	31-1025	12	12-13	10	10-11	265	53-1328
	88-10	28 Sep.	103	379	370-388	0	-	0	-	379	370-388
	88-11	29 Sep.	143	51	35-84	2	2-15	2	2-15	61	39-105
	87-K*	30 Sep.	65.5	43	40-50	47	47-48	68	68-69	157	155-161

[a]Not applicable; confidence interval (C.I.) same as population estimate.

*Control site.

Appendix C, Table C3 Removal-depletion data for mountain whitefish at enhanced and control sites on the Crowsnest River during 1989 (post-construction).

Site	Section Length (m)	SIZE CLASS																					
		Young-of-the-Year (<120 mm)						Juveniles (120-253 mm)						Adult (≥254 mm)						All Size Classes					
		No. Capt./Run					Pop. Est. (95% C.I.)	No. Capt./Run					Pop. Est. (95% C.I.)	No. Capt./Run					Pop. Est. (95% C.I.)	No. Capt./Run					Pop. Est. (95% C.I.)
		R1	R2	R3	R4	T		R1	R2	R3	R4	T		R1	R2	R3	R4	T		R1	R2	R3	R4	T	
88-1	71	4	2	7	16	29	145(29-962)	0	0	1	0	1	1 n.e.[a]	3	2	0	1	6	6(6-8)	7	4	7	18	36	180(36-1071)
88-2	63	570	251	142	30	993	1031(1014-1048)	15	89	40	36	180	900(180-2806)	58	36	26	17	137	168(140-196)	643	376	208	83	1310	1426(1389-1462)
88-3*	52	13	45	27	-	85	425(85-1797)	33	8	3	-	44	44(44-46)	30	7	1	-	38	38(38-39)	76	60	31	-	167	230(176-284)
88-7	57	2	2	0	-	4	4(4-6)	3	1	6	-	10	50(10-538)	9	6	10	-	25	125(25-863)	14	9	16	-	39	195(39-1113)
88-9	49	5	4	22	-	31	155(31-1025)	9	3	0	-	12	12(12-13)	8	2	0	-	10	10(10-11)	22	9	22	-	53	265(53-1328)
88-10	103	284	38	47	-	369	379(370-388)	-	-	-	-	-	-	-	-	-	-	-	-	284	38	47	-	369	379(370-388)
88-11	143	20	2	13	-	35	51(35-84)	0	2	0	-	2	2(2-15)	0	2	0	-	2	2(2-15)	20	6	13	-	39	61(39-105)
87-K*	65.5	22	14	4	-	40	43(40-50)	37	9	1	-	47	47(47-48)	53	15	0	-	68	68(68-69)	112	38	5	-	155	157(155-161)

[a]Not applicable; confidence interval (C.I.) same as population estimate.
*Control site.

APPENDIX D

LENGTH-FREQUENCY DISTRIBUTION AND POPULATION ESTIMATE DATA FOR RAINBOW TROUT (PRE-ENHANCED AND ASSOCIATED CONTROL SITES)

Appendix D, Table D1 Length-frequency distribution of rainbow trout at pre-enhanced and control sites on the Crowsnest River, 1989.

Length Interval (mm)	89-1		89-2		89-3		89-4		89-5		89-6	
	#	%	#	%	#	%	#	%	#	%	#	%
10-19												
20-29					6	2.3	1	0.3			9	2.5
30-39	7	8.6			25	9.4	7	1.9	21	3.9	66	18.7
40-49	12	14.8	7	3.3	56	21.1	40	10.7	60	11.1	74	21.0
50-59	28	34.6	5	2.3	77	28.9	123	32.8	23	4.3	20	5.7
60-69	22	27.2	7	3.3	48	18.0	69	18.4	5	0.9	1	0.3
70-79	9	11.1	2	0.9	8	3.0	35	9.3	13	2.4	16	4.5
80-89	2	2.5	2	0.9			4	1.1	34	6.3	41	11.6
90-99					4	1.5	3	0.8	71	13.1	40	11.3
100-109					1	0.4			59	10.9	24	6.8
110-119			1	0.5	8	3.0	2	0.5	53	9.8	15	4.2
120-129			1	0.5	3	1.1	6	1.6	34	6.3	13	3.7
130-139			1	0.5	4	1.5	2	0.5	28	5.2	6	1.7
140-149	1	1.2	2	0.9	4	1.5	3	0.8	35	6.5	5	1.4
150-159			2	0.9	6	2.3			34	6.3	10	2.8
160-169			5	2.3	4	1.5			21	3.9	2	0.6
170-179			13	6.0	1	0.4			18	3.3	4	1.1
180-189			12	5.6	1	0.4	1	0.3	10	1.8	1	0.3
190-199			17	7.9	2	0.8			5	0.9	2	0.6
200-209			14	6.5			3	0.8	4	0.7		
210-219			17	7.9			9	2.4	4	0.7	1	0.3
220-229			16	7.4			5	1.3	2	0.4	1	0.3
230-239			14	6.5			1	0.3	2	0.4	1	0.3
240-249			13	6.0			3	0.8	2	0.4	1	0.3
250-259			7	3.3	2	0.8	7	1.9				
260-269			14	6.5	1	0.4	9	2.4				
270-279			8	3.7			3	0.8				
280-289			1	0.5	1	0.4	1	0.3	1	0.2		
290-299			5	2.3			8	2.1				
300-309			3	1.4			4	1.1				
310-319			3	1.4	1	0.4	1	0.3	1	0.2		
320-329			3	1.4	1	0.4	3	0.8				
330-339			2	0.9	1	0.4	2	0.5				
340-349			4	1.9			1	0.3				
350-359			2	0.9			2	0.5	1	0.2		
360-369			2	0.9			7	1.9				
370-379			3	1.4			1	0.3				
380-389							1	0.3				
390-399			1	0.5	1	0.4	3	0.8				
400-409			2	0.9								
410-419			4	1.9			1	0.3				
420-429							2	0.5				
430-439												
440-449							1	0.3				
450-459							1	0.3				

Continued...

Appendix D, Table D1 Continued.

Length Interval (mm)	89-7		89-8		89-9		89-10		87-G		87-H	
	#	%	#	%	#	%	#	%	#	%	#	%
10-19												
20-29	4	2.7	2	1.6	7	3.8	9	4.3	1	0.4		
30-39	25	17.1	30	24.4	41	22.5	54	26.0	9	3.7		
40-49	52	35.6	47	38.2	62	34.1	86	41.3	59	24.1	2	1.6
50-59	15	10.3	13	10.6	34	18.7	24	11.5	45	18.4	8	6.4
60-69			4	3.3	13	7.1	1	0.5	24	9.8	7	5.6
70-79	4	2.7			2	1.1	1	0.5	9	3.7	1	0.8
80-89	9	6.2	6	4.9	2	1.1	8	3.8			1	0.8
90-99	11	7.5	11	8.9	7	3.8	5	2.4				
100-109	12	8.2	4	3.3	2	1.1	8	3.8			1	0.8
110-119	5	3.4	4	3.3	6	3.3	4	1.9			6	4.8
120-129	1	0.7	2	1.6	2	1.1	3	1.4			7	5.6
130-139	2	1.4			1	0.5	4	1.9			7	5.6
140-149	1	0.7			2	1.1					3	2.4
150-159	1	0.7							1	0.4	6	4.8
160-169							1	0.5	7	2.9	3	2.4
170-179									10	4.1		
180-189	1	0.7			1	0.5			6	2.4	3	2.4
190-199	2	1.4							13	5.3	5	4.0
200-209	1	0.7							13	5.3	4	3.2
210-219									5	2.0	4	3.2
220-229									7	2.9	1	0.8
230-239									1	0.4	2	1.6
240-249									1	0.4	9	7.2
250-259									4	1.6	4	3.2
260-269									4	1.6	1	0.8
270-279									2	0.8	4	3.2
280-289									4	1.6	2	1.6
290-299									2	0.8	3	2.4
300-309									4	1.6	1	0.8
310-319									1	0.4	7	5.6
320-329									1	0.4	7	5.6
330-339									2	0.8	3	2.4
340-349									1	0.4	3	2.4
350-359									2	0.8	1	0.8
360-369											3	2.4
370-379									1	0.4	1	0.8
380-389									2	0.8		
390-399									1	0.4	1	0.8
400-409											2	1.6
410-419											1	0.8
420-429									2	0.8		
430-439											1	0.8
440-449									1	0.4		
450-459												

Appendix D, Table D2 **Non-standardized estimates of rainbow trout population density (actual estimates for sampled sections), at pre-enhanced and control sites on the Crowsnest River, 1989.**

Enhancement Area	Site	Sample Date	Section Length (m)	SIZE-CLASS							
				Young-of-the-year[a]		Juveniles[b]		Legal (≥254 mm)		All Size-Classes	
				No.	95% C.I.	No.	95% C.I.	No.	95% C.I.	No.	95% C.I.
Near Lundbreck	89-1	24 Sep.	65.0	87	80-97	>1[c]	n.c.[d]	-	-	87	80-97
Near Burmis	89-2	20 Sep.	49.0	38	23-80	165	134-196	63	60-68	258	215-289
	89-3	22 Sep.	50.0	268	236-300	34	34-36	>8	n.c.	297	263-320
	89-4	23 Sep.	69.0	309	290-328	44	37-57	56	56-57	404	375-582
	87-G	21 Sep.	55.0	212	150-274	70	66-77	32	32-33	138	125-151
	87-H	25 Sep.	51.0	19	19-20	69	62-79	51	44-63	286	245-314
Near Coleman	89-5	12 Sep.	64.0	123	109-138	455	439-471	3	3-4	581	541-602
	89-6	10 Sep.	70.0	187	172-202	185	183-189	-	-	367	353-378
	89-7	9 Sep.	43.0	100	96-106	52	50-56	-	-	153	146-161
	89-8	14 Sep.	32.0	100	96-106	27	n.a.[b]	-	-	126	123-131
	89-9	15 Sep.	40.0	160	157-165	26	25-30	-	-	186	182-192
	89-10	11 Sep.	34.0	176	174-180	34	34-36	-	-	211	208-215

[a]At sites 89-1, 2, 3, 4; 87-G, H; length of y-o-y is <100 mm; at sites 89-5, 6, 7, 8, 9, 10; length of y-o-y is <70 mm.
[b]At sites 89-1, 2, 3, 4; 87-G, H; length of juveniles is 100-253 mm; at sites 89-5, 6, 7, 8, 9, 10; length of juveniles is 70-253 mm.
[c]Value given as actual estimate; population estimate would be greater than catch (population estimate not calculable due to ascending or irregular catch progression).
[d]Not calculated.

Appendix D, Table D3 Removal-depletion population data for rainbow trout at pre-enhanced and control sites on the Crowsnest River, 1989.

Site	Section Length (m)	SIZE CLASS																			
		Young-of-the-Year[a]						Juveniles[b]						Legal (≥254 mm)						All Size Classes					
		No. Capt./Run					Pop. Est. (95% C.I.)	No. Capt./Run					Pop. Est. (95% C.I.)	No. Capt./Run					Pop. Est. (95% C.I.)	No. Capt./Run					Pop. Est. (95% C.I.)
		R1	R2	R3	R4	T		R1	R2	R3	R4	T		R1	R2	R3	R4	T		R1	R2	R3	R4	T	
89-1	65.0	51	16	13	-	80	87(80-97)	-	1	-	-	1	>1[c](n.c.)[d]	-	-	-	-	-	-	51	17	13	-	81	87(80-97)
89-2	49.0	9	8	6	-	23	38(23-80)	61	53	18	-	132	165(134-196)	37	19	4	-	60	63(60-68)	107	80	28	-	215	258(215-289)
89-3	50.0	120	67	37	-	224	268(236-300)	24	7	3	-	34	34(34-36)	8	-	-	-	8	>8(n.c.)	152	74	37	-	263	297(263-320)
89-4	69.0	172	74	36	-	282	309(290-328)	18	13	6	-	37	44(37-57)	46	9	1	-	56	56(56-57)	236	96	43	-	375	404(375-582)
87-G	55.0	69	45	33	-	147	212(150-274)	40	20	6	-	66	70(66-77)	27	5	0	-	32	32(32-33)	136	70	39	-	245	286(245-314)
87-H	51.0	13	4	2	-	19	19(19-20)	31	12	14	5	62	69(62-79)	19	9	14	2	44	51(44-63)	63	25	30	7	125	138(125-151)
89-5	64.0	62	31	16	-	109	123(109-138)	283	98	48	-	429	455(439-471)	2	1	0	-	3	3(3-4)	347	130	64	-	541	581(541-602)
89-6	70.0	96	58	16	-	170	187(172-202)	142	31	10	-	183	185(183-189)	-	-	-	-	-	-	238	89	26	-	353	367(353-378)
89-7	43.0	65	21	10	-	96	100(96-106)	31	17	2	-	50	52(50-56)	-	-	-	-	-	-	96	38	12	-	146	153(146-161)
89-8	32.0	67	17	12	-	96	100(96-106)	25	2	0	-	27	27(n.e.)	-	-	-	-	-	-	92	19	12	-	123	126(123-131)
89-9	40.0	119	25	13	-	157	160(157-165)	15	7	3	-	25	26(25-30)	-	-	-	-	-	-	134	32	16	-	182	186(182-192)
89-10	34.0	132	35	7	-	174	176(174-180)	26	4	4	-	34	34(34-36)	-	-	-	-	-	-	158	39	11	-	208	211(208-215)

[a]At sites 89-1, 2, 3, 4; 87-G, K; length of y-o-y is <120 mm; at sites 89-5, 6, 7, 8, 9, 10; length of y-o-y is <100 mm.

[b]At sites 89-1, 2, 3, 4; 87-G, K; length of juveniles is 120-253 mm; at sites 89-5, 6, 7, 8, 9, 10; length of juveniles is 100-253 mm.

[c]Value given as actual catch; population estimate would be greater than actual catch (population estimate not calculated due to ascending or irregular catch progression)..

[d]Not calculated.

APPENDIX E

LENGTH-FREQUENCY DISTRIBUTION AND POPULATION ESTIMATE DATA FOR MOUNTAIN WHITEFISH (PRE-ENHANCED AND ASSOCIATED CONTROL SITES)

Appendix E, Table E1 Length-frequency distribution of mountain whitefish at pre-enhanced and control sites on the Crowsnest River, 1989.

Length Interval (mm)	89-1		89-2		89-3		89-4		89-5		89-6	
	#	%	#	%	#	%	#	%	#	%	#	%
10-19												
20-29												
30-39												
40-49												
50-59												
60-69												
70-79			1	0.3					1	0.6		
80-89			1	0.3	3	7.7	6	2.2	1	0.6		
90-99			2	0.6	14	35.9	38	13.9	1	0.6	1	7.1
100-109					1	2.6	13	4.8	5	3.1	2	14.3
110-119							2	0.7	29	18.0	4	28.6
120-129									62	38.5	3	21.4
130-139									22	13.7	2	14.3
140-149									6	3.7		
150-159			1	0.3					4	2.5		
160-169							1	0.4	4	2.5	1	7.1
170-179							1	0.4	4	2.5		
180-189			2	0.6			2	0.7	4	2.5		
190-199			9	2.8			3	1.1	3	1.9		
200-209			9	2.8					5	3.1		
210-219			4	1.3			1	0.4	4	2.5		
220-229			1	0.3					3	1.9		
230-239			5	1.6			1	0.4			1	7.1
240-249			5	1.6			3	1.1				
250-259			10	3.1			11	4.0	2	1.2		
260-269			26	8.2			14	5.1				
270-279			9	2.8			10	3.7				
280-289			9	2.8	1	2.6	6	2.2	1	0.6		
290-299			19	6.0	2	5.1	8	2.9				
300-309			29	9.1	2	5.1	24	8.8				
310-319			56	17.6	5	12.8	38	13.9				
320-329			33	10.3	4	10.3	35	12.8				
330-339			37	11.6	3	7.7	19	7.0				
340-349			23	7.2	3	7.7	19	7.0				
350-359			14	4.4	1	2.6	13	4.8				
360-369			8	2.5			2	0.7				
370-379			4	1.3			1	0.4				
380-389			2	0.6			2	0.7				
390-399												
400-409												
410-419												
420-429												
430-439												
440-449												
450-459												

Continued . . .

Appendix E, Table E1 Continued.

Length Interval (mm)	89-7		89-8		89-9		89-10		87-G		87-H	
	#	%	#	%	#	%	#	%	#	%	#	%
10-19												
20-29												
30-39												
40-49												
50-59												
60-69												
70-79							4	33.3				
80-89					1	100.0	3	25.0				
90-99									4	1.9	6	4.0
100-109							1	8.3			7	4.7
110-119			2	7.4			2	16.7	1	0.5		
120-129			1	3.7			1	8.3				
130-139			1	3.7			1	8.3				
140-149			3	11.1								
150-159			4	14.8								
160-169			2	7.4					1	0.5		
170-179	1	33.3										
180-189			3	11.1					6	2.9	2	1.3
190-199	1	33.3	4	14.8					16	7.6	3	2.0
200-209			2	7.4					13	6.2	4	2.7
210-219			3	11.1					3	1.4		
220-229	1	33.3									1	0.7
230-239									3	1.4	2	1.3
240-249									5	2.4	3	2.0
250-259			1	3.7					18	8.6	1	0.7
260-269			1	3.7					13	6.2	6	4.0
270-279									7	3.3	11	7.3
280-289									8	3.8	9	6.0
290-299									16	7.6	14	9.3
300-309									16	7.6	13	8.7
310-319									22	10.5	18	12.0
320-329									26	12.4	16	10.7
330-339									12	5.7	23	15.3
340-349									6	2.9	5	3.3
350-359									6	2.9	1	0.7
360-369									5	2.4	4	2.7
370-379									1	0.5		
380-389									2	1.0	1	0.7
390-399												
400-409												
410-419												
420-429												
430-439												
440-449												
450-459												

Appendix E, Table E2 Non-standardized estimates of mountain whitefish population density (actual estimates for sampled sections) at pre-enhanced and control sites on the Crowsnest River, 1989.

Enhancement Area	Site	Sample Date	Section Length (m)	SIZE-CLASS							
				Young-of-the-year[a]		Juveniles[b]		Adult (≥ 254 mm)		All Size-Classes	
				No. per 100 m	95% C.I.	No. per 100 m	95% C.I.	No. per 100 m	95% C.I.	No. per 100 m	95% C.I.
Near Lundbreck	89-1	24 Sep.	65.0	0	-	0	-	0	-	0	-
Near Burmis	89-2	20 Sep.	49.0	4	4-6	48	40-63	276	275-278	323	319-326
	89-3	22 Sep.	50.0	>18[c]	n.c.[d]	0	-	>21	n.c.	41	39-46
	89-4	23 Sep.	69.0	87	59-130	13	13-14	201	201-202	277	273-282
	87-G	21 Sep.	55.0	>5	n.c.	56	56-57	149	149-150	210	210-211
	87-H	25 Sep.	51.0	>57	n.c.	24	16-50	133	119-147	275	208-342
Near Coleman	89-5	12 Sep.	64.0	3	3-4	155	155-156	>3	n.c.	161	161-162
	89-6	10 Sep.	70.0	>1	n.c.	13	13-14	0	-	14	14-15
	89-7	9 Sep.	43.0	0	-	3	3-4	0	-	3	3-4
	89-8	14 Sep.	32.0	0	-	25	n.a.[e]	>2	n.c.	27	n.a.
	89-9	15 Sep.	40.0	>1	n.c.	0	-	0	-	>1	n.c.
	89-10	11 Sep.	34.0	>7	n.c.	6	5-15	0	-	>12	n.c.

[a]At sites 89-1, 2, 3, 4; 87-G, K; length of y-o-y is <120 mm; at sites 89-5, 6, 7, 8, 9, 10; length of y-o-y is <100 mm.

[b]At sites 89-1, 2, 3, 4; 87-G, K; length of juveniles is 120-253 mm; at sites 89-5, 6, 7, 8, 9, 10; length of juveniles is 100-253 mm.

[c]Value given as actual catch; population estimate would be greater than catch.

[d]Not calculated.

[e]Not applicable; confidence interval (C.I.) same as population estimate.

Appendix E, Table E3 Removal-depletion population data for mountain whitefish at pre-enhanced and control sites on the Crowsnest River, 1989.

Site	Section Length (m)	SIZE CLASS																					
		Young-of-the-Year[a]						Juveniles[b]						Adult (≥254 mm)						All Size Classes					
		No. Capt./Run					Pop. Est. (95% C.I.)	No. Capt./Run					Pop. Est. (95% C.I.)	No. Capt./Run					Pop. Est. (95% C.I.)	No. Capt./Run					Pop. Est. (95% C.I.)
		R1	R2	R3	R4	T		R1	R2	R3	R4	T		R1	R2	R3	R4	T		R1	R2	R3	R4	T	
89-1	65.0	0	0	0	-	0	0	0	0	0	-	0	0	0	0	0	0	-	0	0	0	0	0	-	0
89-2	49.0	3	1	0	-	4	4(4-5)	19	15	6	-	40	48(40-63)	225	42	8	-	275	276(275-279)	247	58	14	-	319	323(319-328)
89-3	50.0	4	8	6	-	18	>18[c](n.c.)[d]	0	0	0	-	0	0	21	0	0	-	21	>21(n.c.)	25	8	6	-	39	41(39-46)
89-4	69.0	24	24	11	-	59	87(59-130)	8	5	0	-	13	13(13-14)	176	21	4	-	201	201(201-202)	208	50	15	-	273	277(273-282)
87-G	55.0	5	0	0	-	5	75(n.c.)	44	10	2	-	56	56(56-58)	138	9	2	-	149	149(149-150)	187	19	4	-	210	210)210-211)
87-H	51.0	12	13	15	17	57	>57(n.c.)	6	1	7	2	16	24(16-50)	68	14	20	17	119	133(119-147)	74	28	27	19	192	275(208-342)
89-5	64.0	2	1	0	-	3	3(3-4)	136	12	7	-	155	155(155-156)	3	0	0	-	3	>3(n.c.)	141	13	7	-	161	161(161-162)
89-6	70.0	0	1	0	-	1	>1(n.c.)	10	3	0	-	13	13(13-14)	0	0	0	-	0	0	10	4	0	-	14	14(14-15)
89-7	43.0	0	0	0	-	0	0	2	1	0	-	3	3(3-4)	0	0	0	-	0	0	2	1	0	-	3	3(3-4)
89-8	32.0	0	0	0	-	0	0	24	0	1	-	25	25(n.a.)[e]	2	0	0	-	2	>2(n.c.)	26	0	1	-	27	27(n.a.)
89-9	40.0	1	0	0	-	1	>1(n.c.)	0	0	0	-	0	0	0	0	0	-	0	0	1	0	0	-	1	>1(n.c.)
89-10	34.0	1	3	3	-	7	>7(n.c.)	2	1	2	-	5	6(5-15)	0	0	0	-	0	0						

[a]At sites 89-1, 2, 3, 4; 87-G, K; length of y-o-y is <120 mm; at sites 89-5, 6, 7, 8, 9, 10; length of y-o-y is <100 mm.

[b]At sites 89-1, 2, 3, 4; 87-G, K; length of juveniles is 120-253 mm; at sites 89-5, 6, 7, 8, 9, 10; length of juveniles is 100-253 mm.

[c]Value given as actual catch; population estimate would be greater than actual catch.

[d]Not calculated.

[e]Not applicable; confidence interval same as estimate.